DOCUMENT RESUME

ED 050 347 AC 010 340

AUTHOR	Mooz, W. E.
TITLE	The Pilot Training Study: Personnel Flow and the PILOT Model.
INSTITUTION	Rand Corp., Santa Monica, Calif.
SPONS AGENCY	Department of the Air Force, Washington, D.C.
REPORT NO	RM-6080-PR
PUB DATE	Dec 69
NOTE	81p.
EDRS PRICE	EDRS Price MF-$0.65 HC-$3.29
DESCRIPTORS	*Aircraft Pilots, Computer Oriented Programs, Cost Effectiveness, *Decision Making, *Military Personnel, *Models, *Personnel Data
IDENTIFIERS	PILOT Model, Project RAND

ABSTRACT

The results of the Rand study of pilot flows and the computer-operated decision model, called the PILOT model, are described. The flows of pilots within the Air Force are caused by policies that require the career-development rotation of pilots from cockpit jobs to desk jobs, the maintenance of a supplement of pilots in excess of cockpit-related needs, the cross-training of pilots from one aircraft system to another, and by factors such as retirement, resignation, promotion, and age limitations on flying status. The model has inputs of pilot requirements by year, aircraft system, and type of pilot, plus appropriate descriptions of the various personnel flows. The outputs are the numbers of graduates required each year from the various formal training schools to meet the need for pilots. Problems concerning future training programs, pilot loss rates, and policy variables controlling pilot flows may be examined with the PILOT model. The model may also be used in conjunction with resource and cost models to obtain pilot requirements and statements of personnel flow policy which are translated directly into annual training costs. For related documents, see AC 010 341-347. (Author/DB)

ED050347

U.S. DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
OFFICE OF EDUCATION
THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL OFFICE OF EDUCATION POSITION OR POLICY.

SCOPE OF INTEREST NOTICE
The ERIC Facility has assigned this document for processing to: AC EM
In our judgement, this document is also of interest to the clearinghouses noted to the right. Indexing should reflect their special points of view.

MEMORANDUM
RM-6080-PR
DECEMBER 1969

THE PILOT TRAINING STUDY: Personnel Flow and the PILOT Model

W. E. Mooz

PREPARED FOR:
UNITED STATES AIR FORCE PROJECT RAND

The RAND Corporation
SANTA MONICA • CALIFORNIA

AC 010 310

THIS DOCUMENT HAS BEEN APPROVED FOR PUBLIC RELEASE AND SALE; ITS DISTRIBUTION IS UNLIMITED.

ED050347

MEMORANDUM
RM-6080-PR
DECEMBER 1969

THE PILOT TRAINING STUDY:
Personnel Flow and the PILOT Model

W. E. Mooz

This research is supported by the United States Air Force under Project RAND—Contract No. F44620-67-C-0045—monitored by the Directorate of Operational Requirements and Development Plans, Deputy Chief of Staff, Research and Development, Hq USAF. Views or conclusions contained in this study should not be interpreted as representing the official opinion or policy of the United States Air Force.

DISTRIBUTION STATEMENT
This document has been approved for public release and sale; its distribution is unlimited.

The RAND Corporation
1700 MAIN ST. • SANTA MONICA • CALIFORNIA • 90406

This study is presented as a competent treatment of the subject, worthy of publication. The Rand Corporation vouches for the quality of the research, without necessarily endorsing the opinions and conclusions of the authors.

Published by The RAND Corporation

PREFACE

In April 1967, the Office of the Assistant Secretary of Defense (Manpower and Reserve Affairs) formed a Pilot Advisory Committee to study "Pilots as a National Resource." The Committee consisted of the Assistant Secretary and a representative of each of the three Services. Staff members from Rand were invited to attend the early meetings of the Committee. The outgrowth was that the Air Force member requested Rand to accept responsibility for examining the Air Force pilot training process. The objective of the Rand Pilot Training Study was to develop a series of computer models for use in estimating the resources required to produce pilots and the costs of training them. Further, the models were to be designed for sensitivity analyses and long-range planning.

For the convenience of readers whose interests may not extend to all aspects of the pilot training process, the results of the study are presented in eight volumes, as follows:

Volume		
I	RM-6080-PR	The Pilot Training Study: Personnel Flow and the PILOT Model, by W. E. Mooz.
II	RM-6081-PR	The Pilot Training Study: A User's Guide to the PILOT Model, by Lois Littleton.
III	RM-6082-PR	The Pilot Training Study: Precommissioning Training, by J. W. Cook.
IV	RM-6083-PR	The Pilot Training Study: A Cost-Estimating Model for Undergraduate Pilot Training, by S. L. Allison.
V	RM-6084-PR	The Pilot Training Study: A User's Guide to the Undergraduate Pilot Training Model, by Lois Littleton.
VI	RM-6085-PR	The Pilot Training Study: Advanced Pilot Training, by P. J. Kennedy.
VII	RM-6086-PR	The Pilot Training Study: A Cost-Estimating Model for Advanced Pilot Training, by L. E. Knollmeyer.
VIII	RM-6087-PR	The Pilot Training Study: A User's Guide to the Advanced Pilot Training Computer Cost Model (APT), by H. E. Boren, Jr.

The training of pilots for the Air Force is a process that involves a number of schools and training activities. A civilian wishing to become a USAF pilot must first be commissioned as an officer. To become an officer, he must graduate from either the Air Force Academy (AFA), a college Reserve Officer Training Corps (ROTC) program, or Officer Training School (OTS). He then must go through Undergraduate Pilot Training (UPT), Survival School (SS) and Advanced Pilot Training (APT), as well as some specialty courses.

The officer who becomes a pilot rarely spends his entire career in that capacity. He typically will occupy a variety of flying and non-flying positions. Because of this, the flow of pilots through the training process and to and from the various positions they will occupy is a major factor in the total training cost.

This Memorandum, Volume I of the Pilot Training Study, describes the flow of pilots. It also describes a simulation model, called the PILOT model, that was developed to synthesize the pilot flow. The PILOT model is an analytical device that may be used in the examination of the policies regarding pilot flows, and their consequent effect on training rates. The model may also be used together with resource and cost models (which are described in the companion volumes) for the various formal training activities. When this is done, the combined models integrate the individual training programs into a simulation of the Air Force formal pilot training process. The models, in combination, form an analytical mechanism which is driven by inputs describing pilot requirements and pilot flow policy. This mechanism produces outputs describing the resources required for the various pilot training activities and the total cost of pilot training.

The PILOT model is intended as an aid to long-range planning, that is, a tool by which one may address broad questions concerning pilot training in a time context of 5 to 20 years or more in the future. It is not designed for application to day-to-day management problems which are better treated by management analysis or accounting analysis.

The information presented in this Memorandum may be used by planners and by others interested in the training of Air Force pilots Also, because it provides an overall review of the entire pilot training process, it will be useful as an introduction to the other volumes of the Study.

SUMMARY

This Memorandum describes the results of the Rand study of pilot flows. It also describes the computer-operated decision model that resulted from this study. This model is referred to as the PILOT model.

Early in the pilot training study, it was found that there are complex flows of pilots within the Air Force that affect the total cost of pilot training. These flows are due to policies requiring the career-development rotation of pilots from cockpit jobs to desk jobs, the maintenance of a supplement of pilots in excess of cockpit-related needs, and the cross-training of pilots from one aircraft system to another. The flows are also affected by factors such as retirement, resignation, promotion, and age limitations on flying status.

The model has inputs of pilot requirements by year, aircraft system, and type pilot, plus appropriate descriptions of the various personnel flows. The outputs are the numbers of graduates required each year from the various formal training schools to meet the need for pilots. These schools are as follows:

- o USAF Academy
- o Reserve Officers Training Corps (ROTC)
- o Officers Training School (OTS)
- o Undergraduate Pilot Training (UPT)
- o Survival School (SS)
- o Formal Advanced Pilot Training (APT) schools

Problems concerning future training programs, pilot loss rates, and policy variables controlling pilot flows may be examined with the pilot model. Additionally, it may be used in conjunction with the series of resource and cost models described in the other volumes, listed in the Preface. These resource and cost models are used to estimate the cost of each of the various formal training activities, and each is driven by the numbers of students to be trained. When the resource and cost models are used with the PILOT model, the result is a combination that translates pilot requirements and statements of personnel flow policy directly into annual training costs.

ACKNOWLEDGMENTS

The authors of the eight volumes that constitute the Pilot Training Study are indebted to the many individuals who contributed to the work. Individual acknowledgments are impracticable because a name listing alone would require many pages. The authors therefore take this means of acknowledging their appreciation of the invaluable assistance--the information, counsel, and reviews--that was unstintingly provided by offices of the Air Staff, Headquarters USAF; the Office of the Assistant Secretary of the Air Force (Manpower and Reserve Affairs); the Office of the Assistant Chief (Studies and Analysis); and Headquarters ADC, ATC, MAC, SAC, and TAC. Without this support and that of other professional colleagues, both within and outside Rand, the study could not have been completed.

CONTENTS

PREFACE iii

SUMMARY v

ACKNOWLEDGMENTS vii

Section
I. INTRODUCTION 1

II. DESCRIPTION OF PILOT TRAINING 3
Precommissioning Training 3
Undergraduate Pilot Training 5
Survival School 5
Advanced Pilot Training 6

III. DESCRIPTION OF PILOT FLOW 8

IV. FRAMEWORK FOR A PILOT TRAINING COST MODEL 12

V. THE PILOT MODEL 15
General Description 15
Calculation of Requirements 24
Upgrading Routine 24
Separation of Requirements 24
Division of Pilot Requirements 26
Training Time Calculation 26
UPT Capacity Check 26
APT Load 27
UPT Load 27
Precommissioning Training Calculations 27
Cross-Training Calculations 28
Desk Job Inventory 28
Level of Detail 29
Time Phasing 32
Inputs and Outputs 32

VI. USE OF THE PILOT MODEL 37
Total Pilot Studies 37
Studies by Aircraft Systems 44

Appendix: AUXILIARY ROUTINES FOR USE WITH THE PILOT MODEL 55

I. INTRODUCTION

Several training activities are involved in the production of pilots. One of the first steps in the study, therefore, was to identify each activity or step in the training process so that resource and cost models could be built for each of them. These models would allow the cost of training for each step of the training process to be estimated as a function of the appropriate training variables and statistically derived manpower and cost-estimating relationships. The total cost of producing a pilot for a specific type of aircraft would then be estimated by adding the cost of each increment of training that comprised the total.

Further study brought out the fact that many pilots have had experience (past assignments) with a variety of aircraft. Thus, the total training investment in a pilot of a given aircraft could vary from the cost of the minimum training required for a fresh recruit, to the aggregate training investment in an older pilot with previous training in perhaps as many as six different systems.

Although this method of determining and then totalling the cost of each increment of the training process would be useful in providing answers to explicit questions about the cost of training pilots with a given background of Air Force experience, it was apparent that there were many questions that could not be treated with this approach. For example, "What does pilot training in the Air Force cost in any given year?" Answering this question would require knowledge of each pilot's background so that appropriate cost information about those receiving training during the year in question could be recorded and the costs added. Questions relating to the adequacy of existing training base resources were equally important. Typical of these would be the question of whether there was sufficient UPT capacity available to support an expansion of pilot requirements for a given aircraft. Before this question could be answered, it would be necessary to know how many, if any, of the required pilots were to be cross-trained. An understanding of the demands of competing aircraft systems on UPT capacity would also be required.

Although questions such as these were felt to be of paramount interest to planners, they could not be addressed with a set of resource and cost models alone. A device was required, for use in conjunction with these models, to relate the training in individual schools to the need for pilots in cockpits and to the Air Force policy concerning the rotation of pilots. Such a device, alone, would not answer the above questions but, when used with the resource and cost models, the questions could be addressed. The subject of the Memorandum is the development of a model, designated the PILOT model, that provides the background required.

II. DESCRIPTION OF PILOT TRAINING

Several independent training steps are required to produce a pilot. These steps and the resource and cost models that have been produced for each of them are discussed in detail in other parts of the Pilot Training Study.* The following description of the steps in the pilot training process is, therefore, limited to the minimum considered essential for an understanding of the relationships discussed later in this Memorandum.

PRECOMMISSIONING TRAINING

Present Air Force policy requires that all pilots be commissioned officers. The training leading to a commission is not exclusively oriented towards the production of officers who will be trained as pilots and, for some purposes, it would be inappropriate to treat precommissioning training as part of the pilot training process. However, an incremental requirement for Air Force pilots does produce a requirement for an equal number of commissioned officers and this training requires time and money, both of which must be anticipated. For these reasons, precommissioning training is included in this study. The three sources of commissioned officers are described below.

Air Force Academy (AFA)

The Air Force Academy at Colorado Springs, Colorado, is the Air Force counterpart of the Army's West Point, and the Navy's Annapolis. The Academy program consists of a four-year college curriculum combined with military training. The AFA graduate receives a bachelor of science degree and is commissioned a second lieutenant in the Air Force.

The number of AFA graduates has been increasing in recent years. It is expected to reach approximately 920 in 1973 and then to become relatively fixed at that level. Academy graduates, however, represent a small percentage of those commissioned each year, and, consequently,

*See Preface.

it is improbable that the number of AFA graduates will ever be affected by fluctuations in Air Force needs, either for pilots or for officers in other categories.

The purpose of the Academy is to produce high-quality, career-motivated officers to assure that in later years these specially selected, trained and dedicated individuals will be among those available for assignment to positions of great responsibility.

The Academy requires four years of study and military training to graduate, and thus is the longest of the three processes leading to an Air Force commission. It also is the costliest to the government because all of the college educational costs are borne by the Air Force.

Reserve Officers Training Corps (ROTC)

About 175 colleges have ROTC programs. Over the period 1955-1968, the number of graduates varied between 3300 and 12,200. Commencing with fiscal year 1969 and extending through 1973, the ROTC production objective is to produce about 4500 graduates per year. There are two programs: one of two years' duration and the other four. The final two years of the four-year program is termed the Professional Officer Course (POC). Only those who successfully complete the POC are commissioned.

All ROTC students are given free uniforms and textbooks. Students in POC are given a small monthly allowance. In addition to these benefits, scholarship students receive free tuition and an extra allowance for fees and textbooks.

Because the POC is only a two-year program and because the Air Force does not bear the full educational costs for each ROTC student, the cost per ROTC graduate is much less than the cost of an AFA graduate.

Officer Training School (OTS)

The shortest way to obtain a commission is through the OTS at Lackland Air Force Base, Texas. This school provides military training to qualified college graduates in a 12-week program. Because of the short lead time needed for selection and training of officer

candidates, the OTS output can be increased or cut back quickly in response to changes in Air Force needs. This and the modest cost of OTS make this program adaptable to changing requirements. For these reasons, OTS has traditionally been used to fill the gap between AFA and ROTC outputs and approved officer-production quotas.

In a recent four-year period, the number of OTS graduates varied from about 2600 to 7800. Because of these wide variations in output, average numbers of graduates are not particularly meaningful.

Flight Indoctrination Program

Both the AFA and ROTC commissioning courses include a flight indoctrination program (FIP) for pilot candidates. The FIP uses the same T-41 light aircraft that is used later in undergraduate pilot training (UPT). The purpose of the FIP is to acquaint the pilot candidate with the rudiments of flying and to screen out those who are unsuited for enrollment in UPT.

UNDERGRADUATE PILOT TRAINING

After graduation from the AFA, ROTC, or OTS, the newly-commissioned pilot candidate enters undergraduate pilot training (UPT) at one of ten training bases administered by the Air Training Command (ATC). The UPT is a 53-week program of ground school instruction, simulator training, flying training and military training. The student learns how to fly three increasingly sophisticated aircraft, and graduates as a jet-qualified pilot. In recent years, the annual number of UPT graduates has ranged from about 1400 to over 3000.

The philosophy of UPT is that the graduate, having been taught the general principles of flying, is able by cross-training to qualify as a pilot of any aircraft in the Air Force inventory.

SURVIVAL SCHOOL

The Survival School is operated by the Air Training Command (ATC) at Fairchild Air Force Base, a Strategic Air Command (SAC) base near

Spokane, Washington. It gives survival instruction to all flight crew members, including pilots. Currently, there are two courses, one requiring 15 training days and the other nine. Students are taught basic survival techniques applicable to several different kinds of hostile environment; for example, parachute control and landing; land navigation; first aid; procurement of food from plants, fish and game; and water survival. Over 8000 officers and airmen were graduated in 1968.

ADVANCED PILOT TRAINING

The purpose of advanced pilot training is to qualify a pilot to operate a specific aircraft in which he is not currently rated. The student may have only UPT experience or he may be an experienced pilot assigned, for cross-training, from another aircraft system. He may have several thousand or as few as 240 flying hours experience.

The advanced training with which this study deals is conducted only at formal schools. There are advanced training schools for almost all of the widely used aircraft in the Air Force inventory. Usually, the schools are under the jurisdiction of the major command that is the principal user of the particular aircraft in which the instruction is being given. Several types of aircraft have schools on more than one base in order to accommodate large student loads. In some cases, several different schools are situated on a single base.

Combat Crew Training Schools (CCTS) are the basic activities for advanced training of pilots within the Tactical Air Command (TAC), Aerospace Defense Command (ADC), and Strategic Air Command (SAC). When CCTS training capacities are exceeded, the student overflows are accommodated by Replacement Training Units (RTU) established within tactical units. The courses of instruction are essentially the same. The only salient difference between CCTS and RTU training is that the former are operated by training squadrons with full-time staffs of instructors, whereas operational squadrons conduct the RTU instruction as an added duty while continuing to maintain their operational readiness posture.

The Military Airlift Command (MAC) trains pilots for heavy transport aircraft in a program known as the Transport Training Unit (TTU)

program. Also, MAC provides air rescue training utilizing both fixed- and rotary-wing aircraft. These advanced training courses, like CCTS training, are taught by full-time instructors.

The Air Training Command (ATC) applies the general term Advanced Pilot Training to all ATC courses subsequent to UPT. Currently, the ATC trains helicopter pilots, foreign pilots, and some instructor pilots in its advanced training programs.

After a student has graduated from the appropriate CCTS, RTU, TTU, or Air Training Command APT school, he is assigned to a tactical unit. His training is continued after graduation to assure his continuing proficiency in combat skills and to give him the experience necessary for upgrading from one pilot position to another. This upgrading and continuation training is given on the job--not in formal, full-time courses--and therefore is outside the scope of the Pilot Training Study.

In the context of this Study, Advanced Pilot Training also excludes special weapons schools and special theater survival schools.

III. DESCRIPTION OF PILOT FLOW

As previously mentioned, each of the steps in the pilot training process involves the expenditure of varying amounts of time and resources. Because each of these steps contributes to the cost of producing a pilot, the flow of personnel through the various training steps determines the total cost of pilot training. This flow of personnel is depicted in Fig. 1.

In the simplest case--a steady-state condition in which requirements for pilots in cockpit jobs and loss rates are both constant--the input of civilians must balance the losses from the system. All other things being equal, minor increases or decreases in pilot requirements or system losses may be satisfied by corresponding adjustments in the flow of civilians into the system.

Pilot requirements, however, are rarely stable. They vary from year to year in the total numbers required and they also vary within the total; i.e., in the number of pilots required to man the respective aircraft systems. Further, pilot loss rates constantly change and are largely beyond the control of the Air Force. Minor changes in the loss rates cause large percentage changes in the numbers of civilians required, because of the leverage in the system. For example, if there are 35,000 pilots in the Air Force, and the loss rate is 10 percent, 3500 pilots must be replaced each year by training civilians. A change in the loss rate from 10 percent to 11 percent would increase this number to 3850, for an increase in training requirements of 350 or 10 percent.

To cope with the problems of changes in pilot requirements and with loss rates that are only subjectively predictable, the Air Force has provided for a supplement or "cushion" of pilots who are trained and available, but who are in excess of the immediate needs to man aircraft. This supplement, like the inventory that any business maintains, absorbs the immediate effect of changes and allows planners more time to plan precommissioning and undergraduate pilot training levels. The supplement of pilots is distributed in management jobs at desks throughout the Air Force, as well as in schools and other assignments where

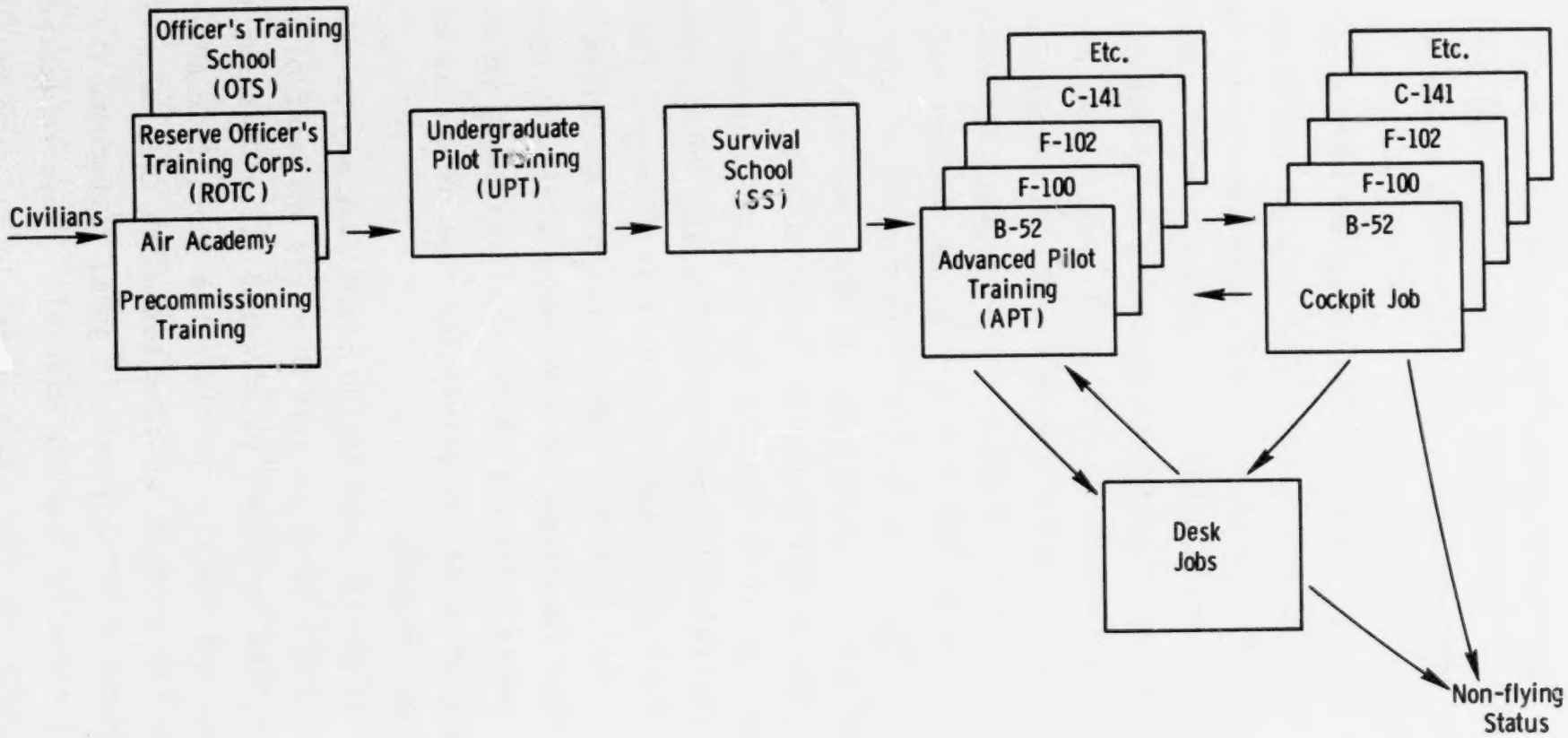

Fig. 1—Pilot flow

flying is not the primary job function. This reserve of pilots is referred to in this Memorandum as pilots in desk jobs, as desk pilots, or as the supplement. These terms do not refer to the required number of pilots in desk jobs but refer, instead, to the number of pilots actually so assigned.

The desired size of the supplement is as subjective as the factors that require it and that control its size. As already stated, loss rates have a large leverage effect. Even more important, the requirements for pilots may expand drastically in a national emergency and may contract with almost equal swiftness following an emergency.

In addition to providing a ready reserve of pilots, the supplement serves as a training ground for managers. The Air Force places an age limit on an officer's flying career because younger men usually have sharper sensory perception and faster reflexes, and are better equipped to pilot today's high-powered and highly responsive aircraft. The experience gained by rotation in and out of desk jobs enables pilots who no longer fly but who remain in the Air Force to qualify for assignment to senior management positions and, thus, lend their experience and maturity to the administration of the complex Air Force organization. Air Force career-development policy, therefore, requires that pilots be rotated through desk jobs even though they are qualified for cockpit assignments. Because rotations are made among different types of aircraft (as well as among different kinds of office jobs) gaps in familiarity with the operation of any particular type or series of aircraft are bridged by cross-training.

Two distinct internal loops in the pilot flow may be identified from Fig. 1. One of the loops is formed by the movement of pilots, first to desk jobs, then from desk jobs to Advanced Pilot Training (APT) bases for cross-training, and finally, to close the loop, from APT to assignments as pilots in the aircraft systems for which they were cross-trained. The second loop, between APT and cockpit jobs, represents the cross-training of pilots directly from one aircraft system to another. There are a number of conditions that cause surges in the size of this second loop. For example, when an aircraft is phased out of service and replaced by another, pilots are cross-trained to man the new system. Also,

a management decision to shorten combat duty tours will require a flow of pilots who must be cross-trained to operate the types of aircraft being used in combat.

As previously stated, the first of the loops results from the deliberate, policy-dictated rotation of pilots for their career development. This rotation is balanced; that is, for each pilot that is rotated into a desk job, another is rotated out and returned to cockpit duty. The career development flow, therefore, is a continuous <u>two-way</u> movement.

Superimposed upon the flow for career development is a flow of pilots between desk and cockpit jobs, dictated by force requirements. Generally, if the number of cockpit jobs increases rapidly, the net flow of pilots will be <u>from</u> desk jobs to aircraft. Conversely, contractions in pilot requirements (also called the "core") cause a net flow of pilots <u>into</u> desk jobs, simply because there is no other place in the Air Force for them. Thus, transfers of pilots from cockpits to desk jobs continue to be made even during periods when there are large drains upon pilots in desk jobs to meet increased cockpit requirements. Conversely, reductions in the numbers of pilots needed for flight duty do not stop the flow of pilots into cockpits from desk jobs.

The elements that control pilot training requirements may be identified, from Fig. 1, as follows:

- Requirements for pilots to man aircraft in active service.
- Size of the pilot supplement.
- Pilot loss rates.
- Rates of pilot rotation through desk jobs.

IV. FRAMEWORK FOR A PILOT TRAINING COST MODEL

The pilot flow described in Section III was shown in Fig. 1. Figure 2 amplifies this by adding the resource and cost models to indicate their relationship to the flow of pilots. The training activities described in Section II are conducted as separate entities, but as shown in Fig. 2, the flow of personnel through the system binds the activities together. Since one objective of the study is to provide a means of estimating the total costs of pilot training, it is necessary to provide a model of the pilot flow, described in Section III, in addition to a cost-estimating model for each of the training activities. The latter models are described in detail in other volumes previously referred to.

The pilot training models allow analyses on several levels of detail. At the most gross level, the effect of variations in the flow rates illustrated in Fig. 1 may be estimated by translating variations in pilot loss rates, pilot requirements, rotational policy and other flow factors into variations in training loads, resource requirements, and training costs. At the most detailed level, the model may be used to address questions concerning training course content because the resource and cost models include components describing the number of flying hours, academic hours, simulator hours, and other elements of the respective training programs.

One important feature of the pilot model is that it is constructed in a "total force context." The model simulates the real world in that inventories of personnel in one year carry forward to the next year in a continuous fashion. Also, as aircraft systems phase out, the pilots thus released are assigned to other jobs.

Another feature is that the model accepts dynamic inputs; that is, the users are free to alter personnel flow factors, syllabuses, and other inputs on a year-to-year basis.

The model also embodies time phasing so that the training loads may be structured over time. This feature is particularly important because a distorted estimate of the training loads is obtained if time

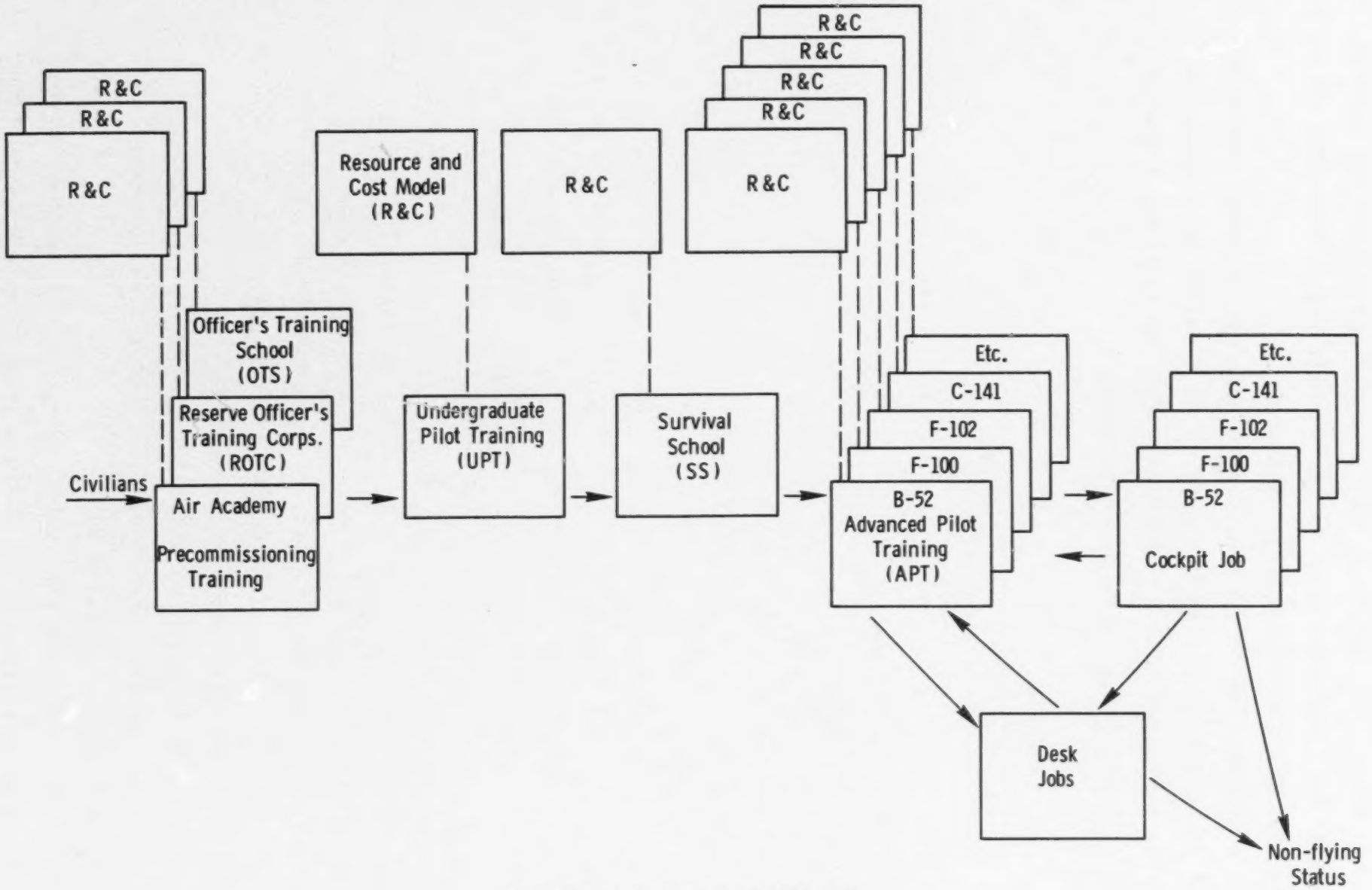

Fig. 2—Overall structure of pilot study

215

phasing is not used. The length of the advanced pilot training courses varies considerably, and time phasing is the only paper method to determine the inputs to advanced pilot training.

With its combination of dynamic inputs and time phasing, the model may be used for predictive purposes such as to identify situations in which existing resources will be inadequate for the training loads or where there is insufficient time to train pilots.

V. THE PILOT MODEL

GENERAL DESCRIPTION

The format shown in Fig. 3 was designed for time-phased representations of the personnel flows depicted in Fig. 1. By showing the passage of time in increments of ΔT on the horizontal axis, and displaying the different stages of a pilot's career on the vertical axis, any personnel pipeline situation may be shown. That is, the career of any pilot may be traced; problems due to changing pilot requirements over time may be graphically illustrated, and training pipelines may be visualized. Examples are shown in Figs. 4 through 9.

Figure 4 depicts a simplified career path for a pilot who progresses through training to a flying job, then to a non-flying job, and eventually to retirement. Figure 5 shows a more common situation in which the pilot is trained, enters a flying job, and then resigns as soon as his obligation is completed. Figure 6 illustrates what can happen in the career of a pilot because of changes in numbers of pilots required for flying jobs. Here, as in Fig. 4, the pilot moves from training to a flying job, then to a desk job (in this example, one in which he is able to maintain his flying proficiency), then to another cockpit assignment, and finally back to another desk job from which he later retires. Figure 7 shows the same career pattern as Fig. 6, except that the pilot is cross-trained to a <u>different</u> type of aircraft. Figure 8 shows cross-training or retraining of a pilot in a non-flying job. These figures are all highly aggregated and simplified illustrations of how this format may be used to portray various paths of pilot careers over time.

The previous figures refer to the path of a single pilot. Figure 9 refers to many pilots and illustrates <u>sources</u> of pilots to fill flying jobs. It has particular applicability to this Memorandum because the requirement for pilots is a driving force for the training model, and Fig. 9 is designed to show this process in the framework of the PILOT model.

Using Fig. 9, assume that the pilot requirements, existing in time period T4, for a particular aircraft (such as B-52 bombers) are forecast

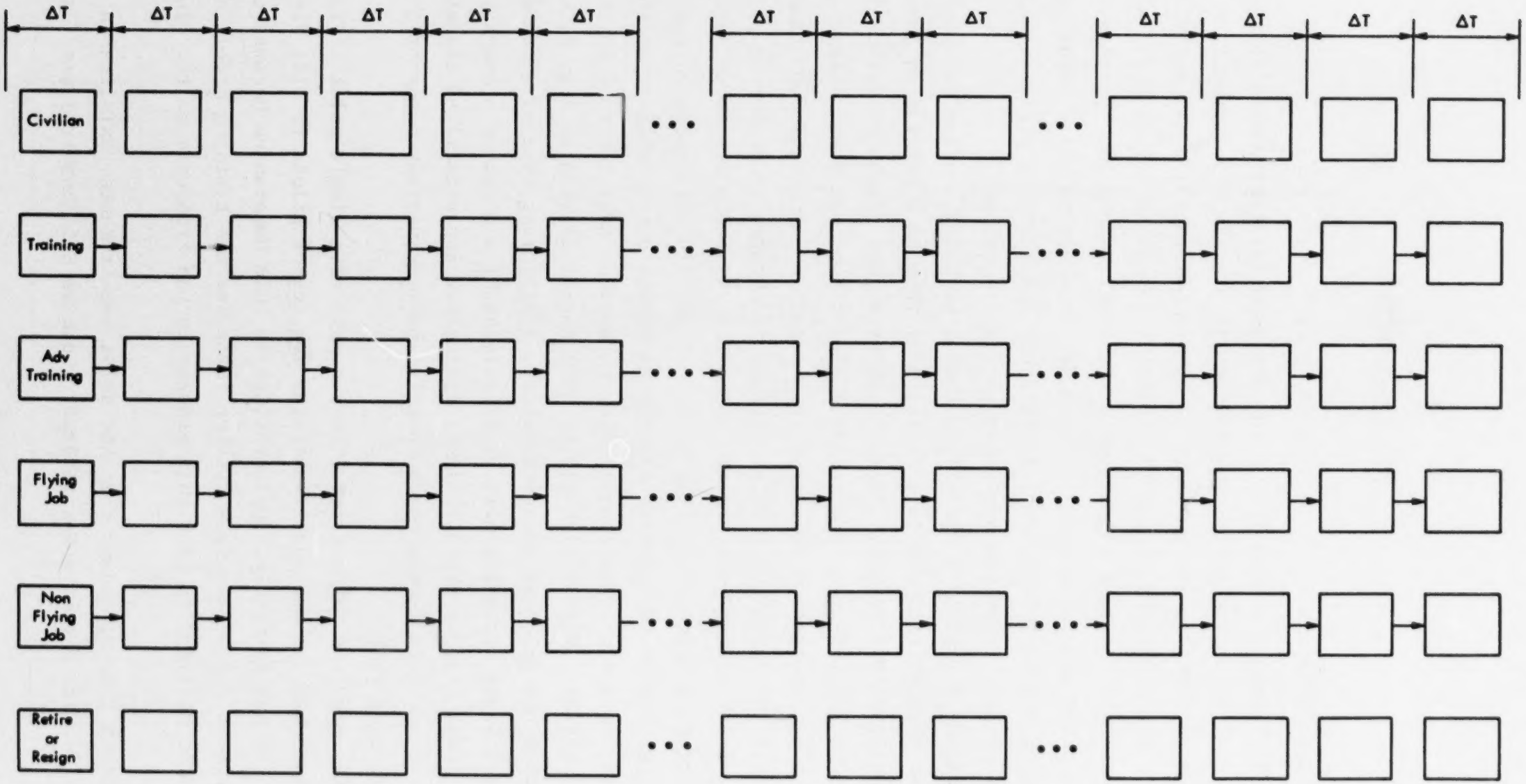

Fig. 3—Time phased representation of Fig. 1

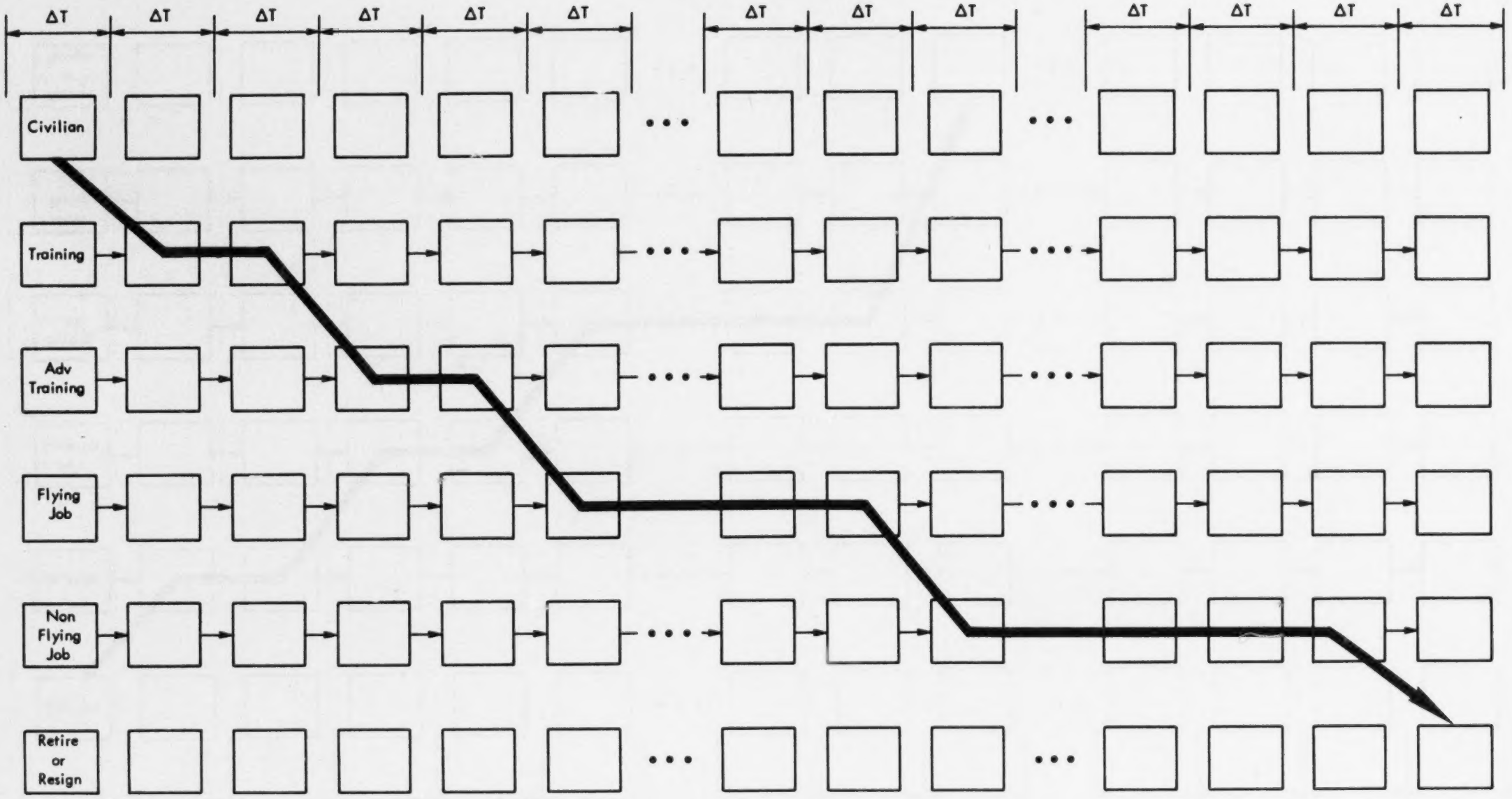

Fig. 4—Simplified personnel flow A

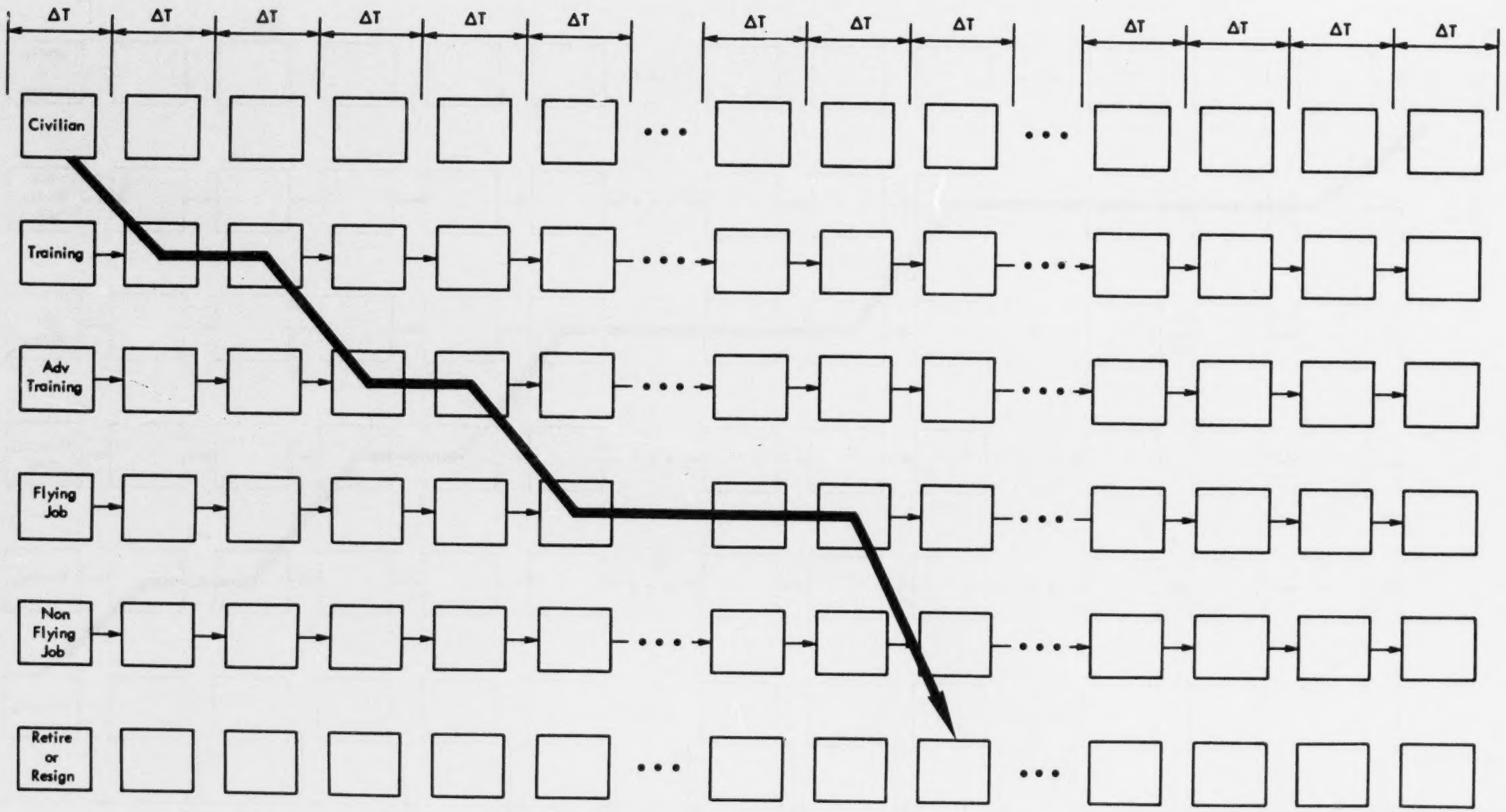

Fig. 5—Simplified personnel flow B

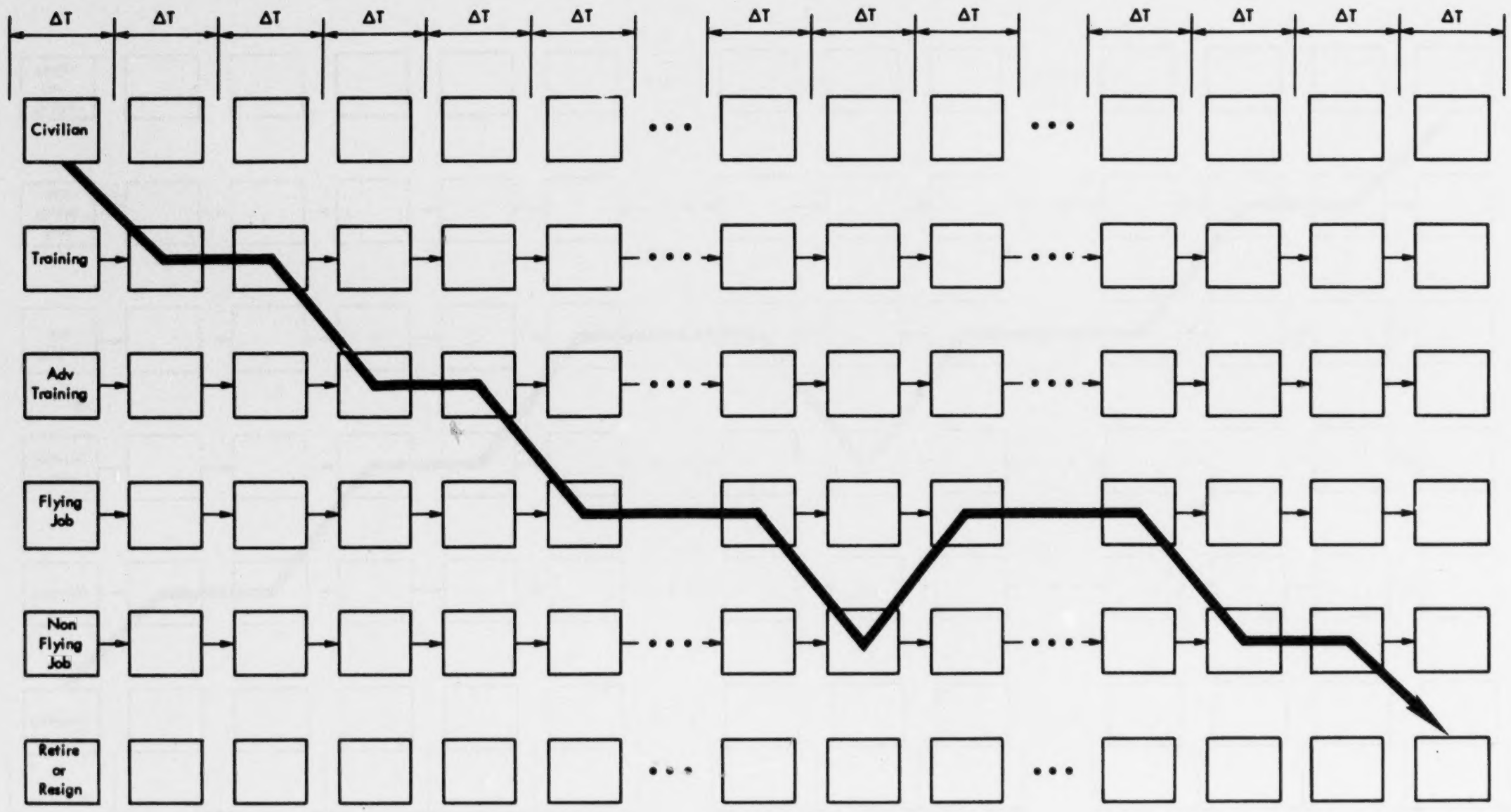

Fig. 6—Simplified personnel flow C

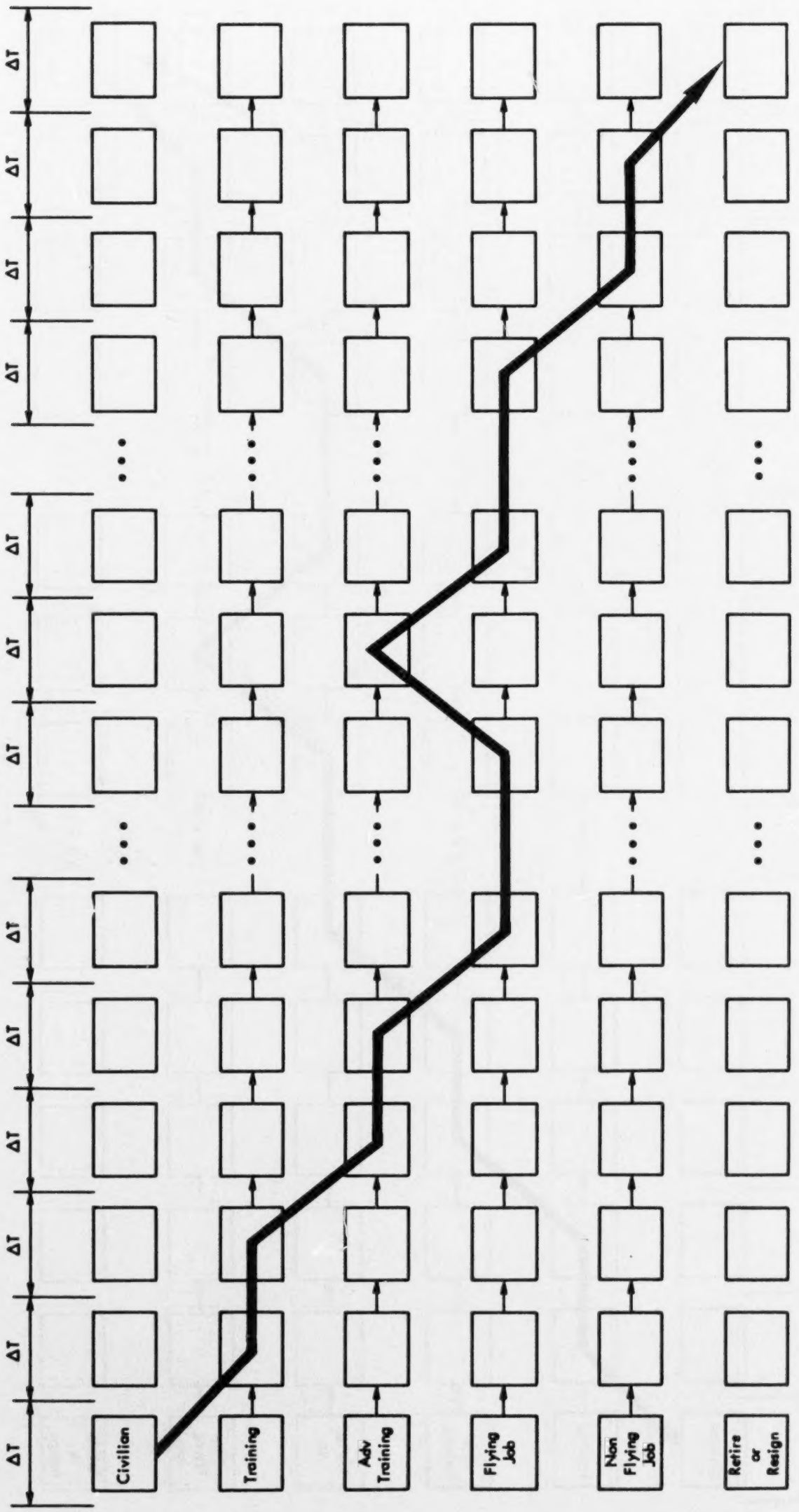

Fig. 7—Simplified personnel flow D

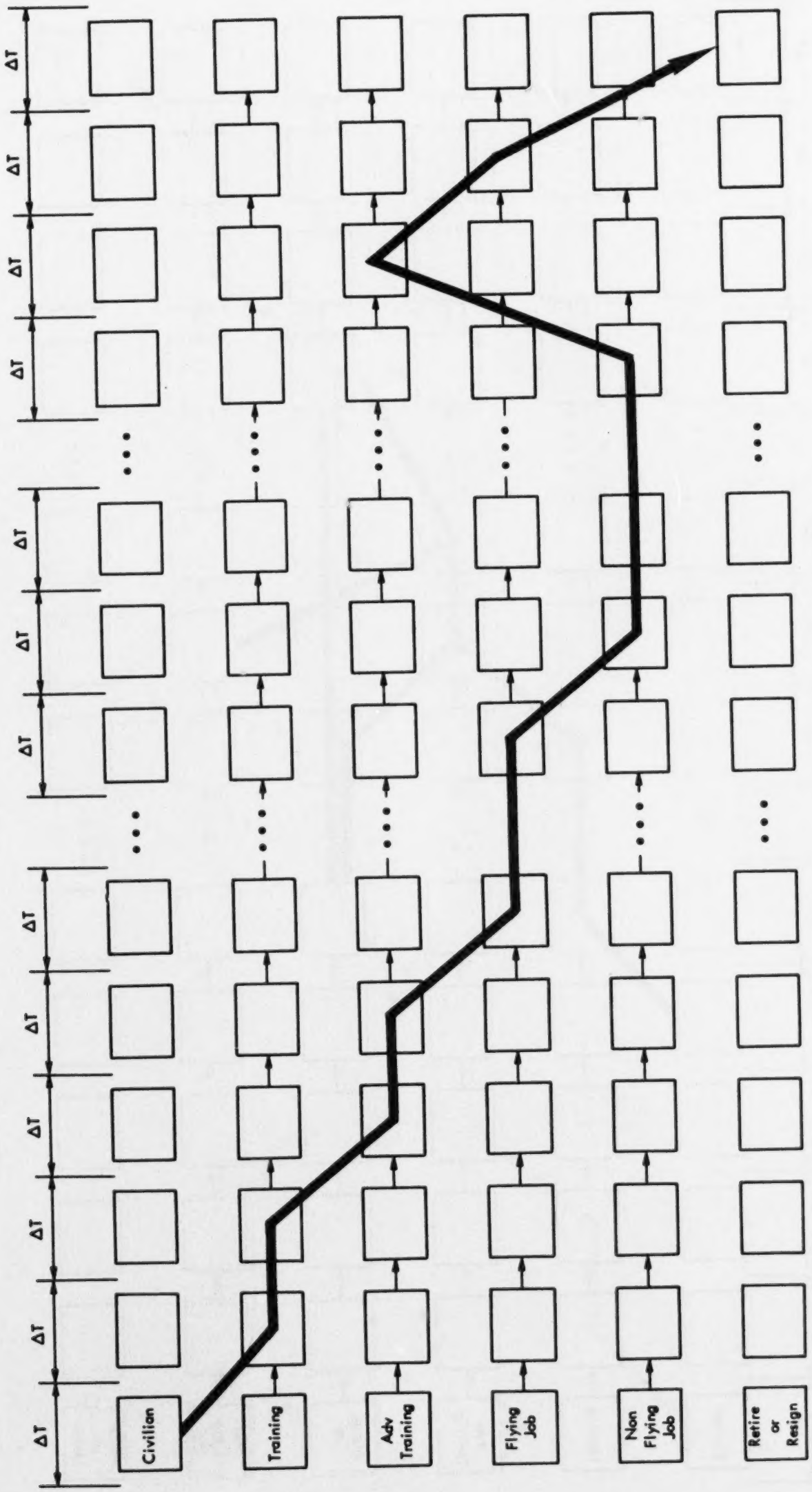

Fig. 8—Simplified personnel flow E

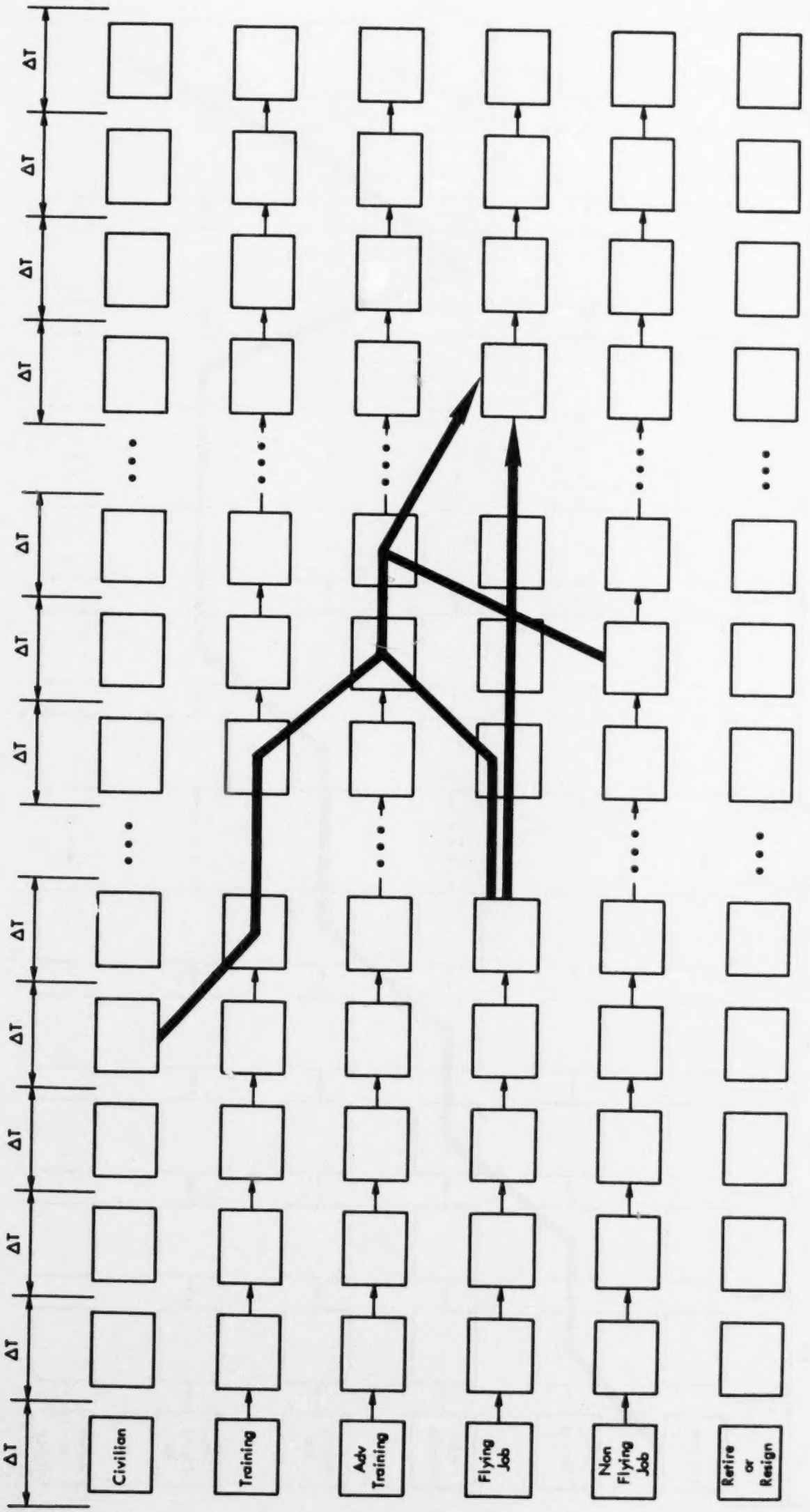

Fig. 9—Sources of pilots to fill a g

to increase in time period T5. Assume that this change in requirements is known at time T1. As shown by the top line of Fig. 9, the availability of this knowledge at time T1 would permit an increased number of civilians to be scheduled into the training process at time T2 to satisfy the requirements of time T5.

Suppose, however, that the change in pilot requirements at time T5 is not known until time T3. At this point, training lead times make it too late to provide the additional pilots needed by an increased civilian input into training. Alternative sources of pilots must be found. As shown in Fig. 9, they consist of:

- o The scheduled (but inadequate) output of new pilots from the training process.
- o Pilots in flying jobs who can be cross-trained to fly the aircraft.
- o Pilots in desk jobs who can be cross-trained to fly the aircraft.

Two other sources (not shown in Fig. 9) are the Air Force Reserve and the Air National Guard. Levies are placed on these reserve forces when the required number of pilots cannot be obtained from other sources and when the requirement arises on such short notice that it cannot be met by cross-training.

Possible variations to the above become obvious when resource and cost requirements are estimated for the incremental training needs dictated by changing pilot requirements. For example, the projected need for pilots at time T5 may be so large that UPT training facilities existing at time T2 will be inadequate to handle the increased load at Time 2. In this event, a more gradual buildup (spreading the required increase in training over the time interval between T1 and T2) may be preferable to an expansion of the training facilities.

Figures 3-9, together with Fig. 1, identify the important elements of the PILOT model. It must have, as driving forces or inputs, statements of the requirements for pilots for cockpit assignments by year together with the appropriate loss rates. The model must allow for the choice of pilot origin (which determines whether and how much cross-training is required). It also must have the ability to simulate desired

levels of career development by rotating pilots into and out of desk jobs.

Figure 10 is a simplified flow chart showing the sequence of the principal steps in the operation of the PILOT model. These steps are outlined briefly as follows:*

CALCULATION OF REQUIREMENTS

This initial step calculates the net pilot requirements ("core") by aircraft system, year, and type of pilot. The calculation compares the inventory of pilots in the previous year, after adjustment for losses and transfers to desk jobs, with the requirement for pilots in the year under examination. The net requirement may be positive, indicating that pilots are needed, or negative, indicating a surplus of pilots.

UPGRADING ROUTINE

This routine examines the requirements for pilots in each aircraft system, and restates them after upgrading pilots within the system according to a hierarchical accession plan. For example, if a two-pilot aircraft system indicated a need for x pilots and y co-pilots, the upgrading routine would translate this into a need for no pilots and x + y co-pilots after upgrading x co-pilots to pilot positions. This routine recognizes the effect of upgrading training by which pilots qualify for upgrading to more responsible pilot positions, e.g., promotion from co-pilot to aircraft commander.

SEPARATION OF REQUIREMENTS

The requirement for pilots for a particular aircraft system may be positive, indicating that pilots must flow into the system. For others it may be negative, as when a system is shrinking in size and has surplus pilots. The positive and negative requirements are treated

*Detailed program information and computer operating procedures for the PILOT model are given in RM-6087-PR (see Preface).

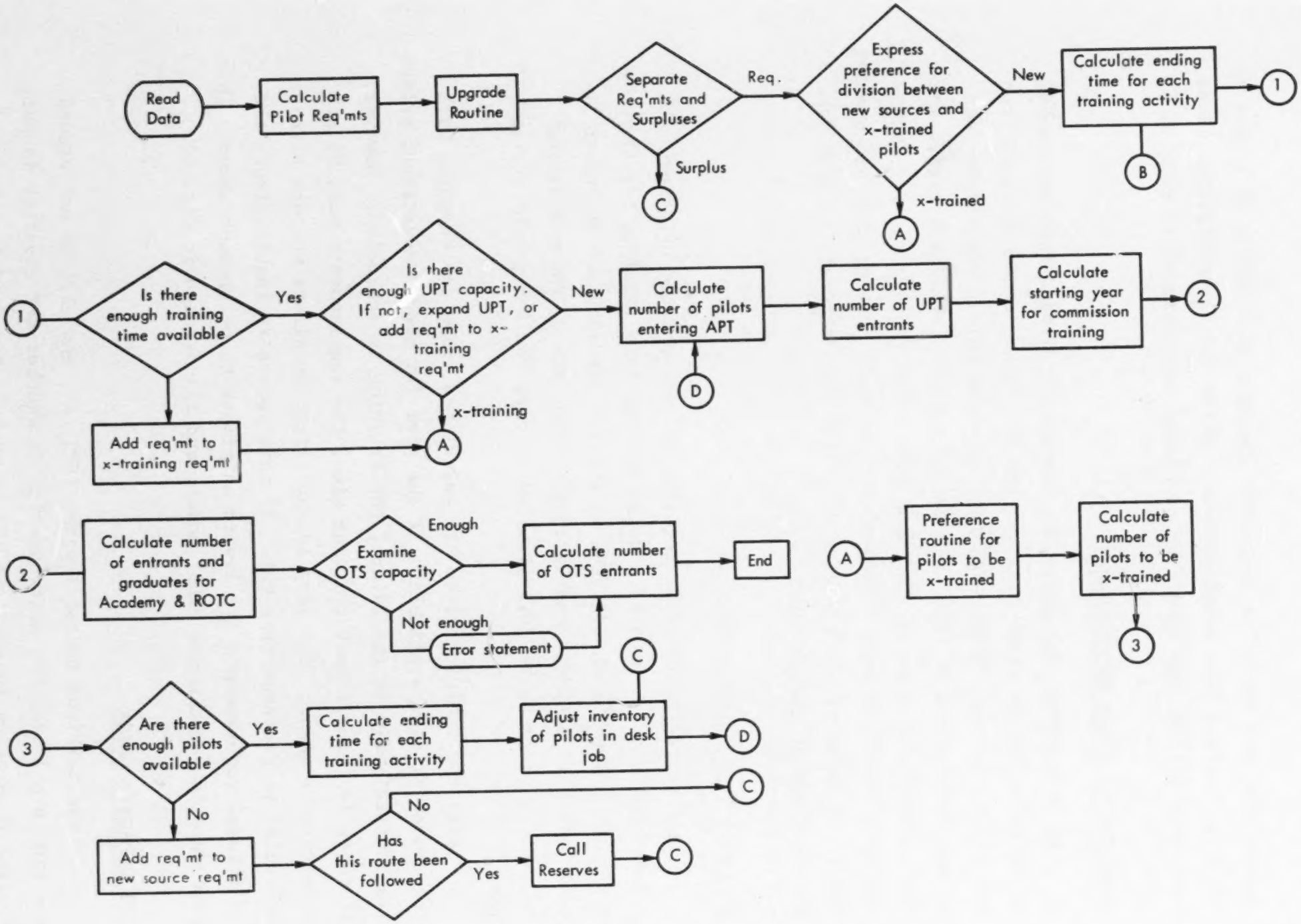

Fig. 10—Aggregated flow chart of PILOT model

separately, and the pilot surpluses are held as a source of pilots to be cross-trained into other systems. After all cross-training needs have been filled, any remaining surpluses are assigned to desk jobs.

DIVISION OF PILOT REQUIREMENTS

At this point, the pilot requirement is divided into the number to be satisfied by cross-training and the number to be obtained from new pilot sources. Cross-training, as shown below, may involve one or any combination of three sources of pilots: similar aircraft systems, dissimilar systems, and desk jobs. The requirement for cross-training absorbs pilots released from aircraft systems that are phasing down, and balances the transfer of pilots from aircraft to desk jobs for purposes of career development.

TRAINING TIME CALCULATION

Data regarding the time required to complete the UPT, Survival School (SS) and PAT courses and the average time required for travel and leave between each of these activities are required as inputs to calculate when students must graduate from each of these training courses in order to be fully trained in time for assignment to cockpit jobs.

After the training times are calculated, they are compared with the amount of time available. If the time for needed additional pilots lies sufficiently in the future, the training is scheduled. However, if there is insufficient training time, the requirements must be met by alternate means. The levy is made first on pilots who are already scheduled to graduate from UPT. If this source is insufficient, the additional requirements are levied on pilots to be cross-trained. This procedure is used in the PILOT model, and illustrated in Fig. 10.

UPT CAPACITY CHECK

If the combined course lengths (UPT, SS, and APT) do not exceed the time available, the next question is whether UPT capacity is sufficient to provide inputs into APT in numbers required for the production of APT-qualified pilots. There are several possibilities:

- o The training capacity may be sufficient.
- o It may be insufficient but able to be expanded in time to accomplish the training.
- o It may be insufficient and the needed expansion either is not allowed or cannot be completed soon enough.

As stated above, if a shortage in UPT capacity cannot be resolved by expansion, the unsatisfied portion of the requirement is met by increasing the number of pilots to be cross-trained. Conversely, the desired UPT training load may have to be increased to qualify pilots for subsequent entry into advanced training for a particular aircraft system (e.g., B-52) when it will not be possible to satisfy a future need for additional pilots for that system through APT cross-training.

APT LOAD

Advanced pilot training for many aircraft systems is conducted in two course lengths. The shorter course is for pilots whose previous assignment was with a similar-type aircraft and who, therefore, can be trained more quickly than those who lack such familiarity. The number of pilots comprising the APT load for each aircraft system equals the additional pilot requirement for that system after adjusting for attrition losses. The qualitative content of the APT load, reflected by the assignment of students to short and long courses, is determined by the background of the pilot entering APT.

UPT LOAD

The number of UPT graduates required is calculated from the number of pilots to come from new pilot sources and the attrition during APT. The number of UPT entrants is determined by the graduate requirement, the proportion of the students from the various commissioning sources, and the attrition rate of each of these sources within UPT.

PRECOMMISSIONING TRAINING CALCULATIONS

The model calculates both the number of students to be admitted

to precommissioning training and the time at which they must be admitted. The calculation is based on the following:

- Required number of pilot candidates to be graduated.
- Year in which pilots are required.
- Respective lengths of the AFA, ROTC and OTS precommissioning programs.
- Attrition experience at each school.

At this point, the OTS capacity* is examined and, if expansion is necessary and there is sufficient time, it may be expanded. If it cannot be expanded, either because of preference or lack of time, a statement to this effect is printed.

CROSS-TRAINING CALCULATIONS

There are three sources of pilots for cross-training. In the PILOT model, they are identified as pilots from similar aircraft, pilots from dissimilar aircraft, and pilots from desk jobs. The user of the model is allowed a choice as to the sequence in which he desires to draw upon each source to meet the cross-training quota. The model then compares the number desired with the number available, by source, and makes appropriate adjustments. If there are insufficient pilots in all three of the sources, the shortage becomes an additional requirement for pilots from new sources. A check is also made to prevent the formation of a continuous loop such as would result if pilot requirements were to exceed both the training capacities of the Air Force and the supplement of pilots in desk jobs. When this happens, the computer prints out a message indicating that the shortage must be levied against the Reserve Forces.

DESK JOB INVENTORY

Each year, calculations are made to update the inventory or supplement of pilots in desk jobs. Added to this inventory are the career

*As explained earlier, OTS, being the most flexible of the three officer-training sources, is expected to fill the annual officer-production quota not met by AFA and ROTC.

development rotations, unused surpluses, and attritions from APT classs classes. Subtracted from it are pilots who enter cross-training and pilots who retire, resign, reach the age of 45 with 22 years in rated pilot status or who otherwise become losses from flying status.

Other features not illustrated in Fig. 10 follow.

LEVEL OF DETAIL

Choice of the level of detail for any model is one key to its ability to adequately simulate the real world. The more detailed the model, the more closely it can duplicate reality, but as it becomes more complex the number of inputs tend to be unmanageable. The PILOT model is an excellent example of this. Within recent years, the Air Force has had as many as 45,000 pilots. Most of them have served in desk jobs as well as cockpit jobs. The ultimate level of detail would provide the ability to identify and track each of these pilots individually over the time span allowed by the model. This, of course, would require a model so complex that it could not be effectively used even if it could be constructed.

The PILOT model accepts inputs of pilot requirements (or core) stated in terms of type pilot, aircraft system, and year. The maximum capacity of the model is three types of pilot, 80 aircraft systems, and 20 years. The level of detail or composition of the model and its limitations are explained below in terms of includes and excludes.

Pilot Categories

The PILOT model deals with three categories or pilot qualification levels. These are identified as aircraft commanders, 1st pilots, and 2d pilots.* The term "aircraft commander" is self-explanatory. A co-pilot is either a 1st pilot or a 2d pilot, depending on his proficiency and the number of flying hours he has logged. Of course, where only one co-pilot is used, only two pilot inputs are required--pilot and co-pilot. For single-seat aircraft, only one type of pilot--the aircraft commander--is identified.

*These are the classifications used by the Military Airlift Command.

The upgrading routine automatically advances 1st pilots to aircraft commanders, and 2d pilots to 1st pilots wherever there are vacancies. It does this without knowing what the requirements are for such advancement or whether they have been met. It is assumed that, on the average, 1st and 2d pilots qualify for advancement more quickly than the opportunities to advance occur; that is, there is always a line of qualified applicants awaiting openings.

Desk Jobs

The PILOT model does not differentiate among types of desk jobs or the flying qualifications of pilots who are to fill them; that is, these assignments, unlike enrollments in cross-training courses (see below), are made without regard to whether the pilot is bomber- or fighter-qualified, and without regard to how much experience he has. The separate identification of desk jobs according to whether occupied by a bomber pilot or a fighter pilot would serve no useful purpose and, in any case, would be complicated by the fact that many pilots have been cross-trained in both types of aircraft. The PILOT model, therefore, treats all desk jobs as being the same, the assumption being that the mix of pilot experience and the mix of job requirements will match.

Long and Short Advance Pilot Training Courses

As explained earlier, the PILOT model treats each APT program as though it consisted of a long course and a short course. Actually, some schools may have courses of more than two lengths. The situation is further complicated, because the APT schools are permitted, at their discretion, to vary a student's period of training (extend or shorten the established formal course length) taking into account the individual student's ability. These variations are ignored in the model because they represent a small percentage of the total APT training and their inclusion in the model would therefore create an unnecessary complication.

Pilots who are experienced in similar type of aircraft and who have not had an intervening desk assignment are automatically enrolled in the short course. Pilots assigned directly from UPT and pilots assigned directly from dissimilar aircraft systems (i.e., bomber pilots who are to be cross-trained as fighter pilots, and vice versa) are automatically enrolled in the long course. Because pilots in desk jobs are not identified as either bomber or fighter pilots, they too are assumed to require the long course.

Seniority and Experience

The PILOT model deals in numbers of personnel. There is no identification of age, rank, longevity, or experience, except as may be inferred from the training category (AFA, ROTC, OTS, UPT, SS, APT short course or APT long course) or flight assignment (aircraft commander, 1st pilot, or 2d pilot). Pilots are moved from flying jobs to desk jobs and vice versa, based on percentage factors, the assumption being that, whatever the source, qualified personnel will be available in sufficient numbers to permit all of the desired transfers to be made.

Adequacy of Facilities

Tests are made of the respective capacities of the UPT and OTS physical plants. The PILOT model first makes a check to determine whether the capacities are sufficient for the student loads. If not, it merely signals that fact without indicating whether the shortage falls short of requirements by, for example, 10 or 1000 students. It then proceeds into a followup routine to answer the question: "Is there sufficient time for facility expansion?" Again, the model merely gives a "yes" or "no" answer, with no quantitative information.

It is recognized that a training facility shortage of 1000 spaces presents a widely different situation from a shortage of only 10 (as in the example above), but it is also recognized that an excess of students does not automatically result in an expansion of the training facilities. The decisionmaking process is a complex one entailing considerations of options and political and fiscal constraints that cannot

be readily built into the model. The purpose of incorporating the facilities routine in the PILOT model, therefore, is to alert the user to the problem of capacity by providing him with "yes" or "no" answers to the twin questions: "Is the existing capacity inadequate?" and, if so, "Can it be expanded in time to overcome the shortage?"

TIME PHASING

The basic time increment of the PILOT model is the year. Some inputs for training time lengths are in terms of days, but these are internally converted to fractions of a year and summed with other training times as appropriate. Outputs of the model appear as numbers of students entering and graduating from the training activities per year. Because of this, sensitivity to changes in course lengths, travel or leave times, is only seen when the change is sufficient to swing the output from one year to another.

Time phasing and level of detail are closely associated. The PILOT model has been built to handle a 20-year period in 1-year increments. Although it is possible to adjust the values of the inputs so that the model operates in different sized increments (for example, for a 5-year period of 20 quarters, or for a 20-month period) this should not be done. The model has not been built to handle the additional detail, and attempts to use it for time increments shorter than one year are improper and will produce misleading results.

INPUTS AND OUTPUTS

The PILOT model inputs may be divided into decision inputs and factor inputs. The former represent the elements that alter the policy of flow of pilots through training; the latter represent historical and estimated data concerning attrition losses in training, the length of the training courses, and similar information. There are about 45 different inputs, but the dimensioning of these is such that the total number of input cards may be quite large. Tables 1 and 2 list the inputs together with their dimensions. In each case the dimensions indicated are maximum, and in practice any number between one and the

Table 1

PILOT MODEL DECISION INPUTS

Nomen-clature	Identification	Dimension
A1	Number of pilots required in aircraft system	N,W,T
A2	Fraction of pilots desired from new pilot sources	N,W,T
A5A	Fraction of pilots rotating from aircraft to desk jobs for career development purposes	N,W,T
A10	Cross-training preference index--similar aircraft	W
A11	Cross-training preference index--dissimilar acft	W
A12	Cross-training preference index--pilots in desk jobs	W
A63	Is UPT expansion allowed?	N
A66	Is OTS expansion allowed?	N

Table 2

PILOT MODEL FACTOR INPUTS

Nomen-clature	Identification	Dimension
A3	Number of pilots in desk jobs for N=1	1
A4	Fractional yearly loss rate for pilots in desk jobs	N
A5	Fractional yearly loss rate for pilots in cockpits	N,W,T
A6	Fractional yearly loss rate in APT	N
A7	Aircraft type (bomber/cargo or fighter)	W
A9	Number of UPT graduates in the pipeline	N
A16	Number of Air Force Academy graduates entering UPT	N
A17	Number of ROTC graduates entering UPT	N
A18	Number of rated-officers entering UPT	N
A19	Number of non-rated officers entering UPT	N
A20	Number of others entering UPT	N
A21	Fractional loss rate in UPT of Air Force Academy graduates	N

Table 2 (Cont.)

Nomen-clature	Identification	Dimension
A22	Fractional loss rate in UPT of ROTC graduates	N
A23	Fractional loss rate in UPT of OTS graduates	N
A24	Fractional loss rate in UPT of rated officers	N
A25	Fractional loss rate in UPT of non-rated officers	N
A26	Fractional loss rate in UPT of others	N
A27	Fractional loss rate in Air Force Academy	N
A28	Fractional loss rate in ROTC	N
A29	Fractional loss rate in OTS	N
A62	UPT capacity in year N=1	1
A64	Number of days required to expand UPT	1
A65	OTS capacity in year N=1	1
A67	Number of days required to expand OTS	1
T1	Number of days travel and leave after APT	1
T2	Number of days travel and leave after Survival School	1
T3	Number of days travel and leave after UPT	1
T4	Number of days travel and leave after commissioning	1
S1	APT course length, days	N,W,2
S2	Survival school course length, days	N
S3	UPT course length, days	N
S41	Air Force Academy course length, days	1
S42	ROTC course length, days	1
S43	OTS course length, days	1

maximum may be used. Nomenclature for dimensioning is listed as N, W, or T. N refers to the year and has a maximum value of 20. W refers to aircraft system and may equal 80. T identifies pilot type, and may be a maximum of 3. A dimension of 1 indicates that the input is used only once.

Outputs from the model consist of listings of the training activities by numbers of entrants and annual graduates. There is also a tabular statement of the number of pilots in desk jobs for each year.

The PILOT model, as described above, produces output statements of the requirements through each of the pilot training activities, including UPT. This is descriptive of the ideal situation in which the training of personnel is responsive only to the needs for these personnel. This situation does not take into account the problems of adjusting a large-scale training operation, such as UPT, to rapidly changing throughputs. In the analysis of pilot training it is desirable to understand the changing demands for trained pilots and the model describes these succinctly. For planning purposes, however, it may also be desirable to be able to specify a fixed level of UPT training which may or may not be directly responsive to the needs of the force over time. In a situation where this was done, the UPT output would steadily feed into the force at whatever level was established. If the need for pilots exceeded the UPT output, the deficit would be made up by transferring pilots from desk jobs to cockpit positions. If fewer pilots were required than were graduated from UPT, the reverse would occur and the size of the supplement would be increased.

The PILOT model cannot handle this latter situation directly. This is because the program has not been designed to handle cases where the UPT output exceeds the need for pilots. When this situation occurs in reality, the excess pilots are used by moving the required number of pilots from cockpits into desk jobs, and replacing them with the new pilots. In the PILOT model there is no method of applying appropriate decision criteria so that the required number of pilots would be moved into desk jobs from selected aircraft systems. In addition, since the model is time phased, pilots required in a stated year may graduate from UPT in as many as three different years, due to the varying APT

lengths. Another way of stating this is that a given year's UPT production may be assigned to cockpit jobs in up to three different years, depending on the length of APT for the various aircraft systems. The time phasing is done internally, and consequently the model user has no prior way to know how many UPT graduates from one year will be assigned to each aircraft system and in which year they will be assigned. This further complicates the problem of attempting to develop methodology for the model which would accommodate fixed UPT outputs.

Recognizing that it would be desirable to study cases in which the UPT output was fixed, an auxiliary program was developed that uses input information about the fixed levels of UPT training and the force size to produce output factors describing the flow of pilots in the force. This auxiliary program is described in the appendix. It is useful in certain types of study, but has severe limitations in that all pilots must be treated as belonging to a single aircraft system.

VI. USE OF THE PILOT MODEL

As stated in Section IV, the PILOT model provides inputs to drive the precommissioning, UPT, and APT models. Also, as with the other models making up the pilot training cost model, the PILOT model may be used alone. This Section illustrates some uses of the PILOT model itself as a tool for analyses of pilot training flows.

TOTAL PILOT STUDIES

For some analytical purposes, it is convenient to look at the total number, or core, of Air Force pilots without regard to which aircraft systems they fly. In the PILOT model, this may be accomplished by treating all pilots as one type, that is, as belonging to a single aircraft system. This highly aggregated approach may be used to examine broad questions concerning the size of the supplement and concerning gross training rates through the various training activities. It also serves as a convenient and relatively simple method of demonstrating the use of the model. When this technique is used, the aggregation of the inputs prevents the use of resource and cost models in conjunction with the PILOT model.

Determination of Supplement Size and Training Loads

Figure 11 illustrates a hypothetical variation in core size over a 12-year period. By using this information as a basic requirement and by varying certain of the decision inputs, the flexibility of the PILOT model may be illustrated. In each of the examples, the decision inputs (from Table 1)* are assigned values as follows:

		shown in
A1	(number of pilots required in acft system)	Fig. 11
A2	(fraction of pilots from new pilot sources)	0.62

*Decision inputs A10, A11, and A12 (cross-training preferences) are not applicable because, for purposes of illustration, it is assumed that there is only one aircraft system.

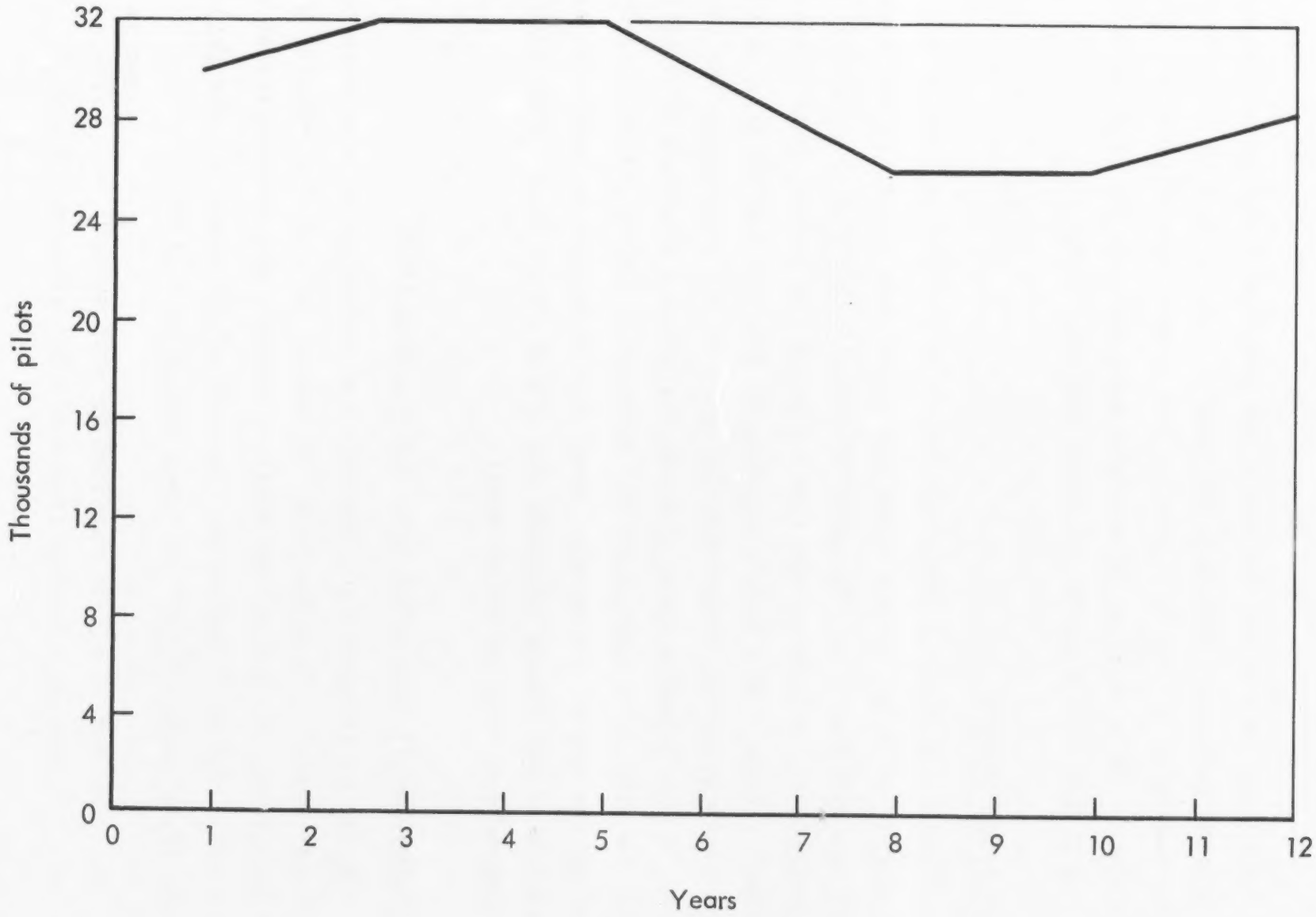

Fig. 11—Pilot requirements

A5A	(fraction of pilots transferring from aircraft to desk jobs)	0.08
A63	UPT expansion allowed.	
A66	OTS expansion allowed.	

The factor inputs, from Table 2, are all historical figures that are held constant throughout the illustrative cases, except for the annual pilot loss rates A4 and A5 which, for Case 1, are set at 0.12.

Outputs are plotted in Fig. 12 as Case 1, and illustrate the graduate requirements from UPT and APT and the size of the supplement of pilots in desk jobs. The outputs shown as Case 1 were the result of constant values for A2 and A5A for all years. Modification of the output values may be achieved by changes in the inputs for the appropriate years.

Increases in the value of A2 cause more new recruits to enter UPT, thereby increasing training through UPT, and raising the size of the supplement. Decreases in A2 cause the opposite effect, and if carried to an extreme, could exhaust the supplement completely by failing to provide sufficient new pilots to offset losses from the force. No change in the APT load results from changing A2.

Increasing the fraction of pilots transferring from aircraft to desk jobs (A5A) has several effects. First, it results in an increase in the size of the supplement by transferring more pilots to desk jobs. This then raises the net requirement for pilots to fill cockpits, which in turn is reflected as a larger demand on UPT and commission training. It also reflects as a greater demand for cross-trained pilots, and this, together with the increase through UPT, increases the load on APT.

Case 2 is plotted in Fig. 13, and shows the effect of changing the value of A5A from 0.08 to 0.10.

Figure 13 illustrates a situation in which both the training loads and the size of the supplement vary widely. If it is assumed, for example, that the maximum capacity of UPT is approximately 3900 graduates per year, then the information shown in Fig. 12 takes on new significance. It shows that in most of the years under examination the requirements through UPT are less than the UPT capacity, but in several years the requirements exceed capacity. This suggests that by

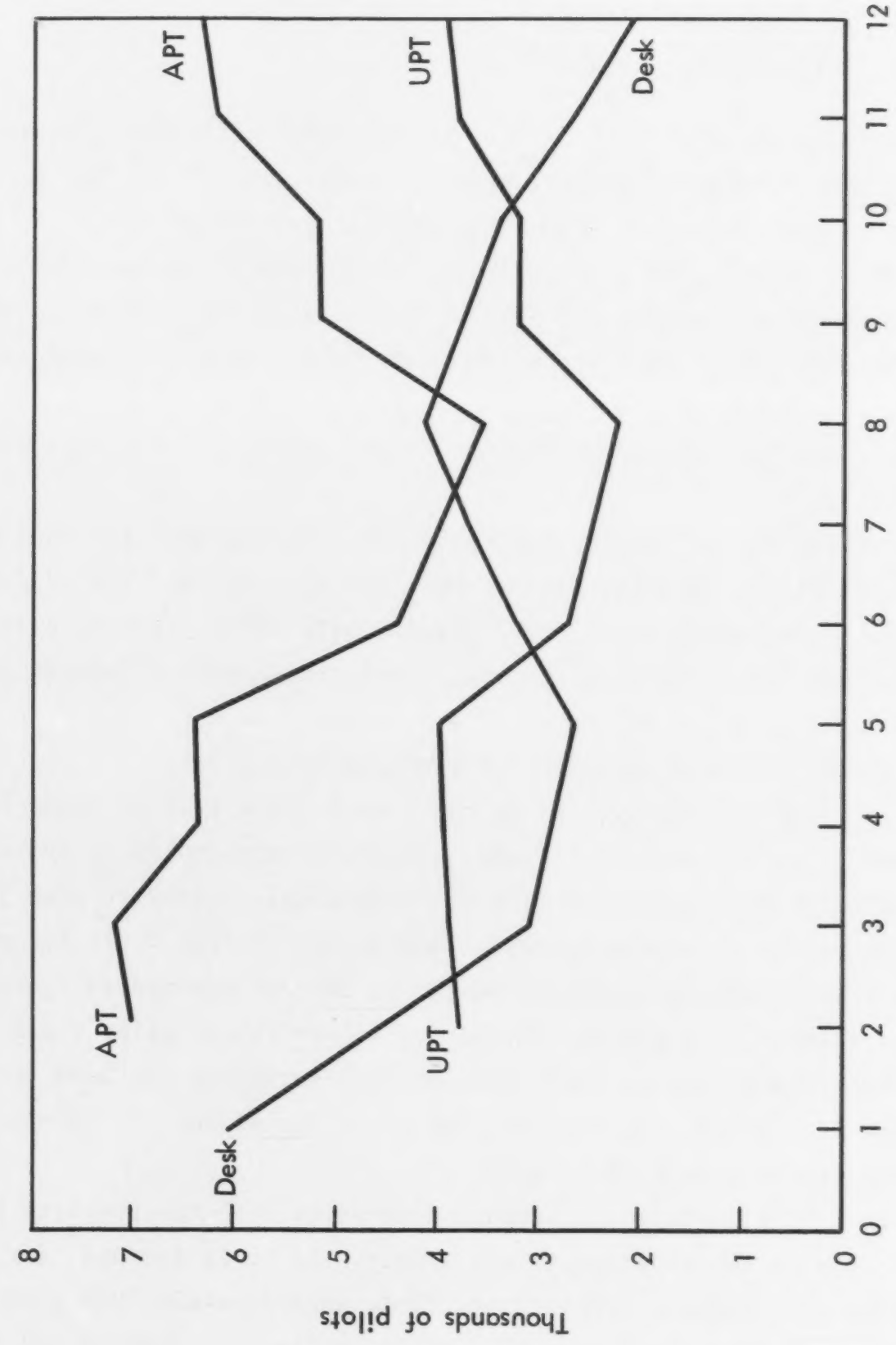

Fig. 12—Training loads and number of pilots in desk jobs. Fraction of pilots transferring from aircraft to desk jobs = 0.08.

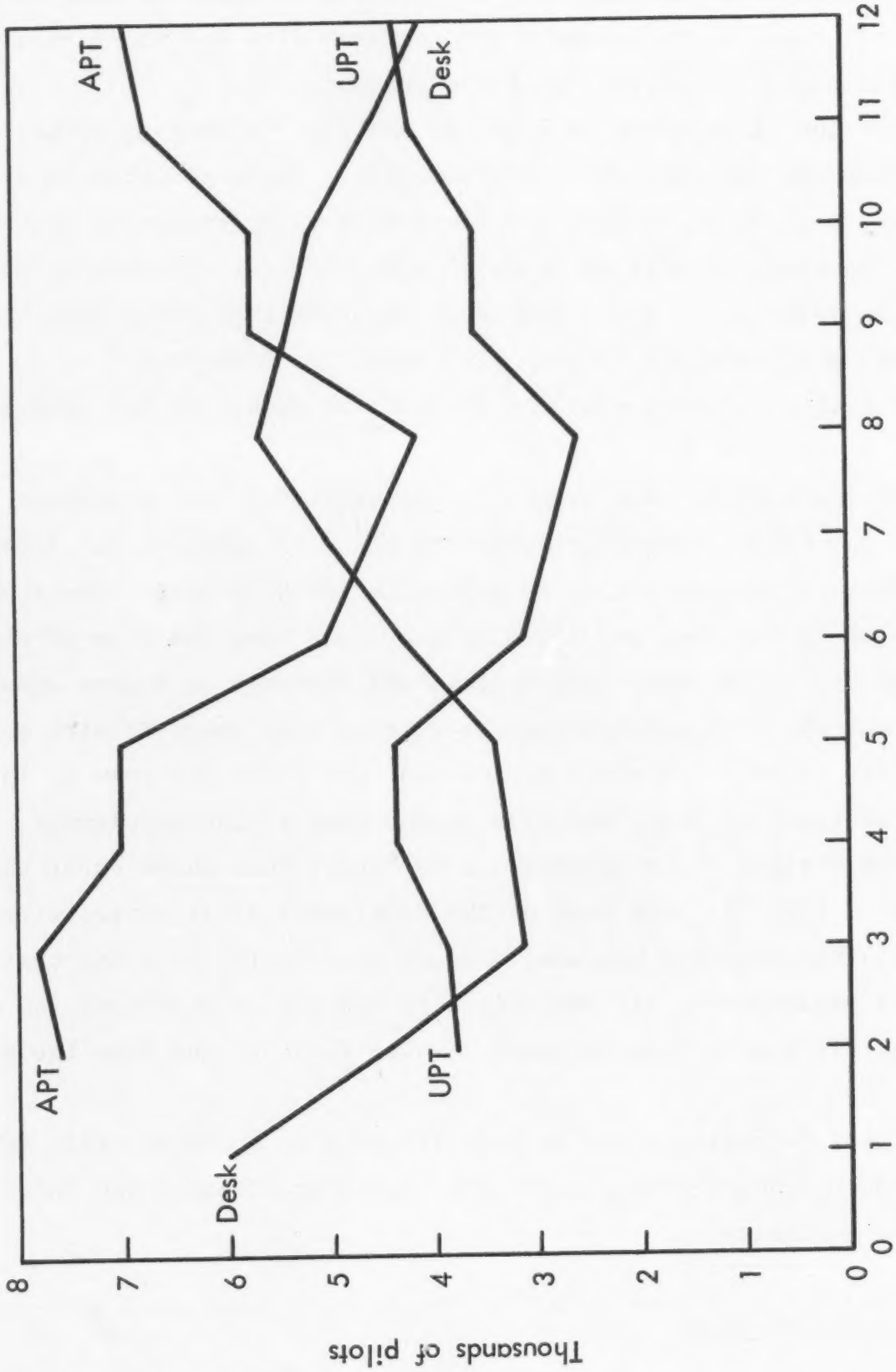

Fig. 13—Training loads and number of pilots in desk jobs. Fraction of pilots transferring from aircraft to desk jobs = 0.10.

smoothing the flow through UPT, two objectives might be simultaneously achieved; that is, to create a more uniform flow and to eliminate the need for expansion in the few surge years.

For the cases shown in Figs. 12 and 13, the average number of UPT graduates are 3394 and 3686, respectively. It is possible to alter the inputs so as to achieve a uniform flow using either of these figures. However, if this is done, it will reduce the number of UPT graduates in years 3, 4, and 5 and cause an additional drain upon the supplement, which already reaches its lowest point in year 5.

A better solution would be to hold the number of UPT graduates at the maximum of 3900 through year 5, and to reduce it to an average of 3500 thereafter. The proper values of A2 and A5A to achieve this result may be determined by using Routine 1 of Appendix A. Rotation for career development will be maintained at 8 percent. The results are shown in Fig. 14, and the effect of smoothing the flow of pilots through UPT is evident. Not only is UPT operated at a more steady rate, but the advanced training program is also operated with a more consistent load. The extra pilots that are processed show up in the advanced training load, and also in the size of the supplement, causing the peak size of the supplement to be higher than shown under the condition of Fig. 12. The size of the supplement still varies widely, but this must be expected because, when an essentially constant training rate is established, all variations in cockpit requirements (as shown in Fig. 11) must be accommodated through flows to and from the supplement.

The information shown in Fig. 14 could be modified still further to produce other desired conditions, again by altering the input factors as necessary.

Sensitivity Analysis

If it is assumed that the training loads and supplement size shown in Fig. 14 are acceptable for planning purposes, one may ask how the situation as shown would change if some of the important factors were to vary. One factor which is not predictable with great certainty is the pilot loss rate. In Fig. 14, an annual loss rate of 12 percent

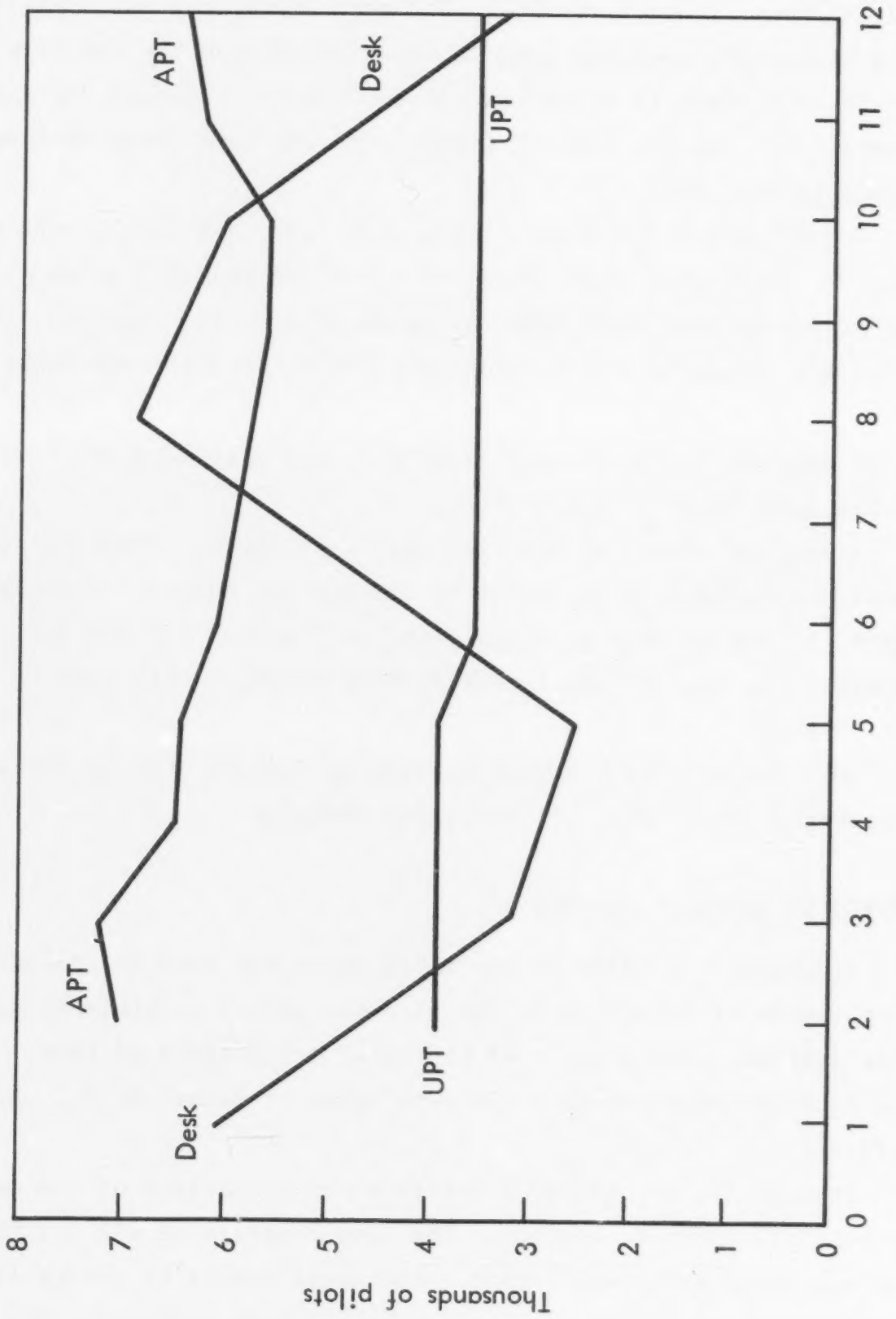

Fig. 14—Training loads and number of pilots in desk jobs with smooth UPT loading

was assumed. If this rate is increased and the UPT training rate is held as shown, it will result in a larger drain from the supplement, and a higher APT training rate in those years when the net flow of pilots is from desks to cockpits. If the loss rate should decrease, the converse will occur. This is illustrated for loss rates of 8 and 12 percent in Fig. 15.

The situation resulting from a loss rate of 8 percent and a constant UPT production might be undesirable, in that it forces large numbers of pilots into desk jobs, as shown in Fig. 15. Instead, the number of UPT graduates may be reduced so as to maintain the number of pilots in desk jobs identical to the pattern in Fig. 14. This information appears in Fig. 16 and shows both the decreased UPT requirements and the lower rate of APT training.

A similar study may be based upon a variation in the rotation for career development, which directly affects the advanced training load. Figures 14 and 15 used an annual rate of 8 percent of the cockpit strength. In Fig. 17 the consequence of altering this rate to 3 percent is shown.

Analyses may also be made by varying factors such as the attrition rates within UPT, APT, or commission training.

STUDIES BY AIRCRAFT SYSTEMS

Aggregative studies as described above may also be conducted at other levels of detail, with the ultimate detail possible being 80 aircraft systems, each capable of employing three types of pilot. Graphical interpretation of this ultimate level of detail is extremely difficult.

Figures 18, 19, and 20 illustrate the capability of the model using multiple aircraft systems. The case consists of six aircraft systems and spans a 12-year period. The total number of pilots in the six aircraft systems is the same as in the previous examples. The strength of each aircraft system varies over time in simulation of the real world, with several systems phasing in or out. Figure 18 illustrates the need for pilots by aircraft system, and also describes the systems.

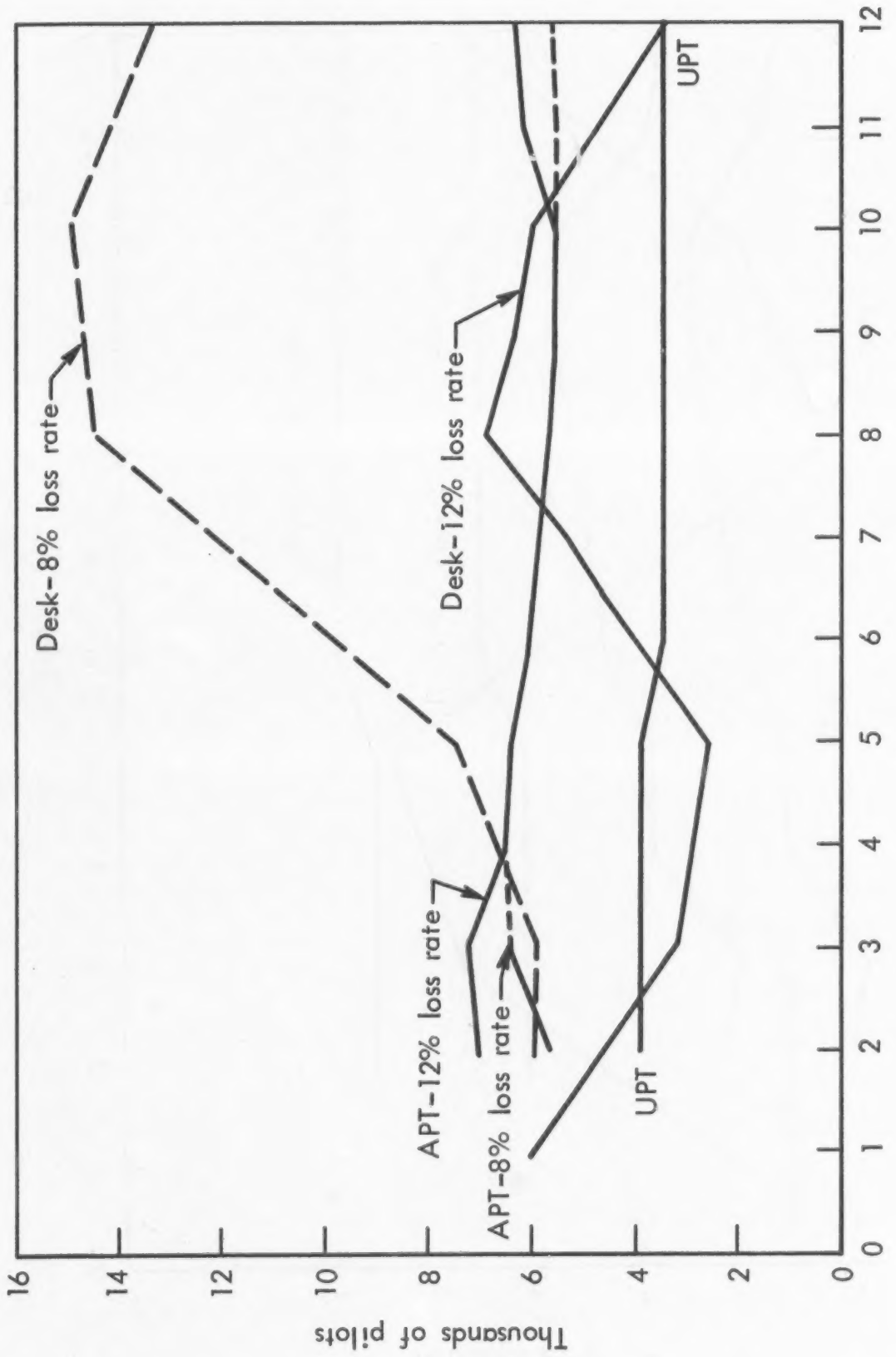

Fig. 15—Effect of variations in pilot loss rate

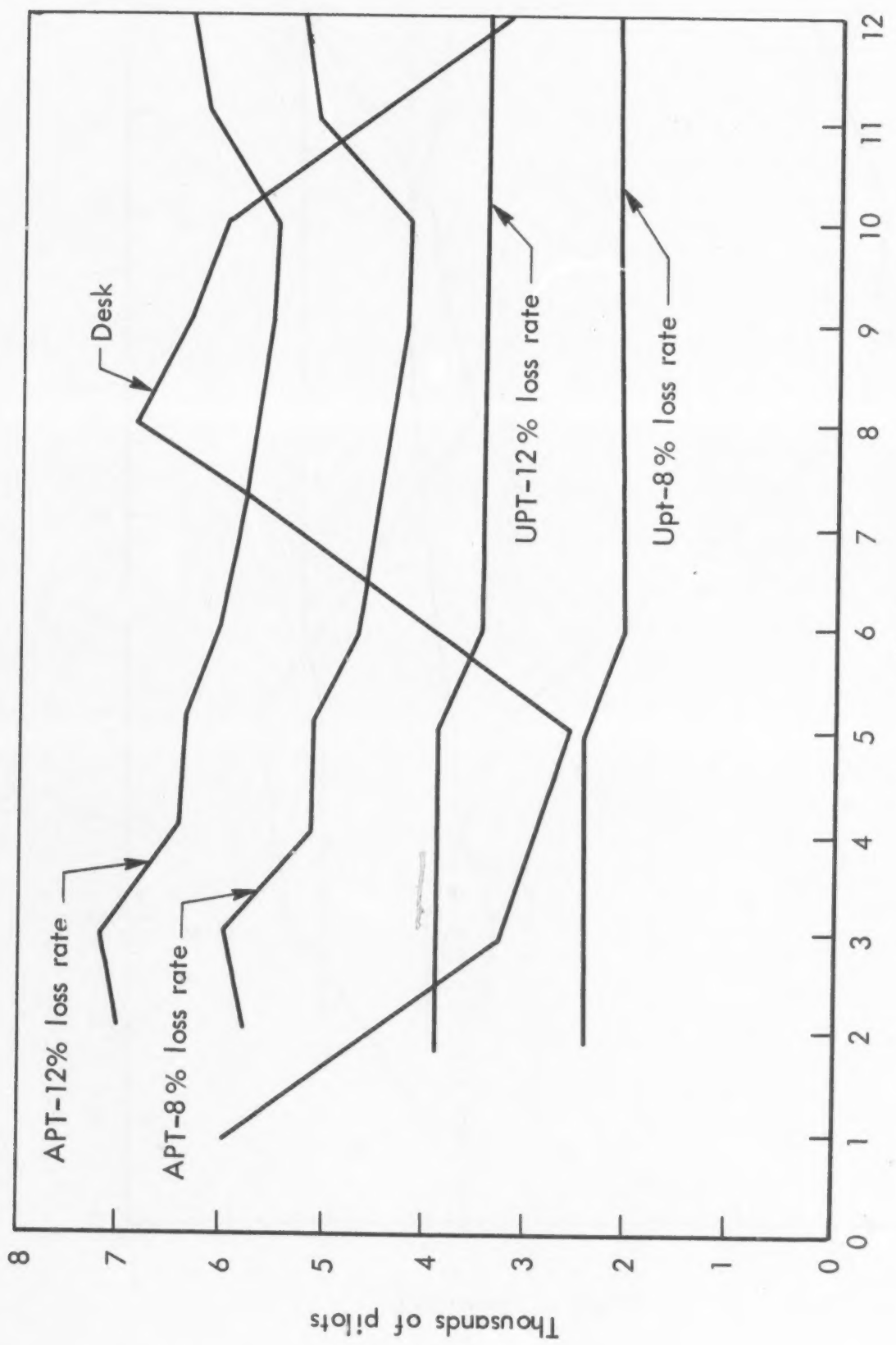

Fig. 16—Effect of variations in pilot loss rate

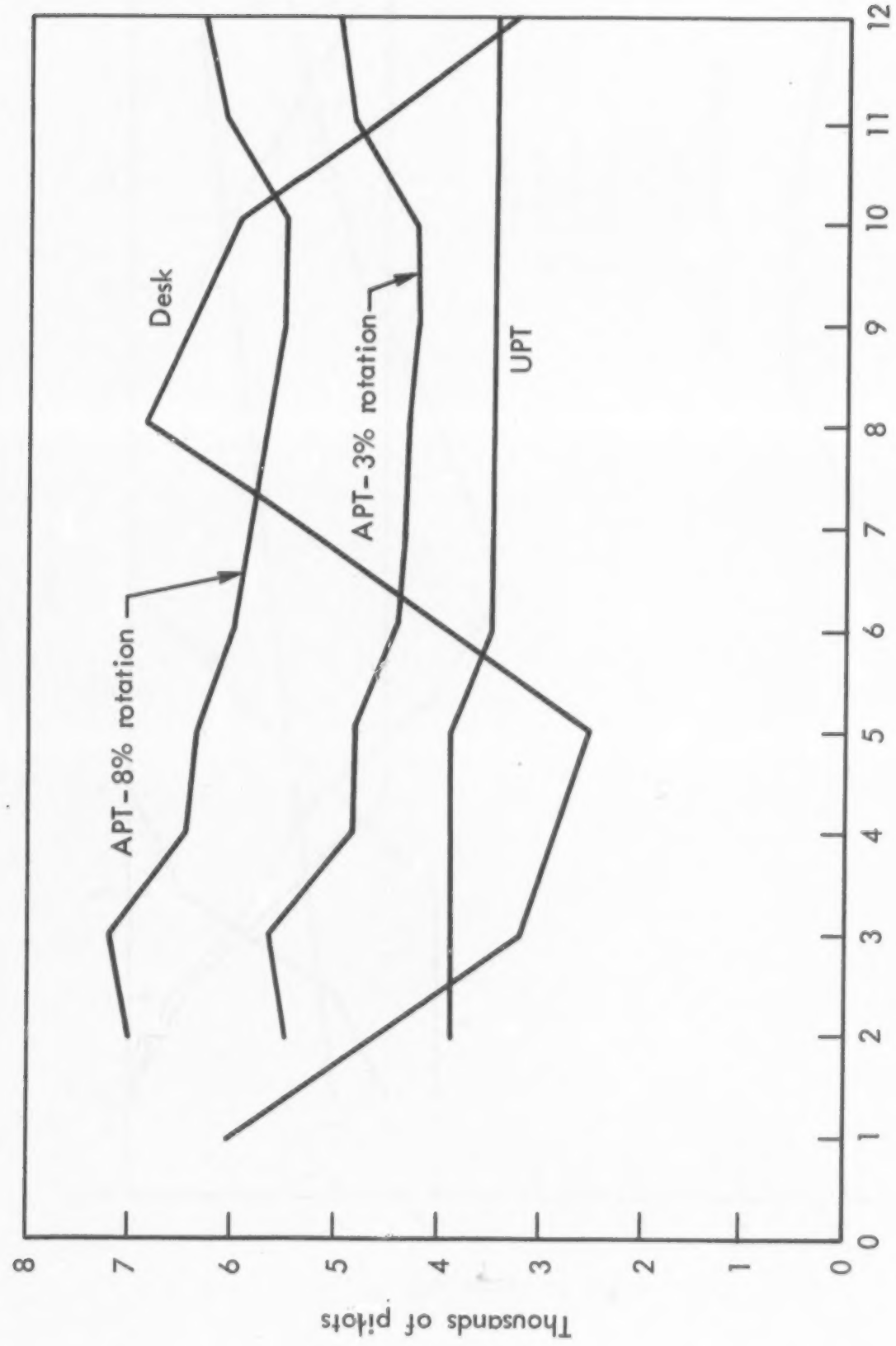

Fig. 17—Effect of variations in rotation for career development

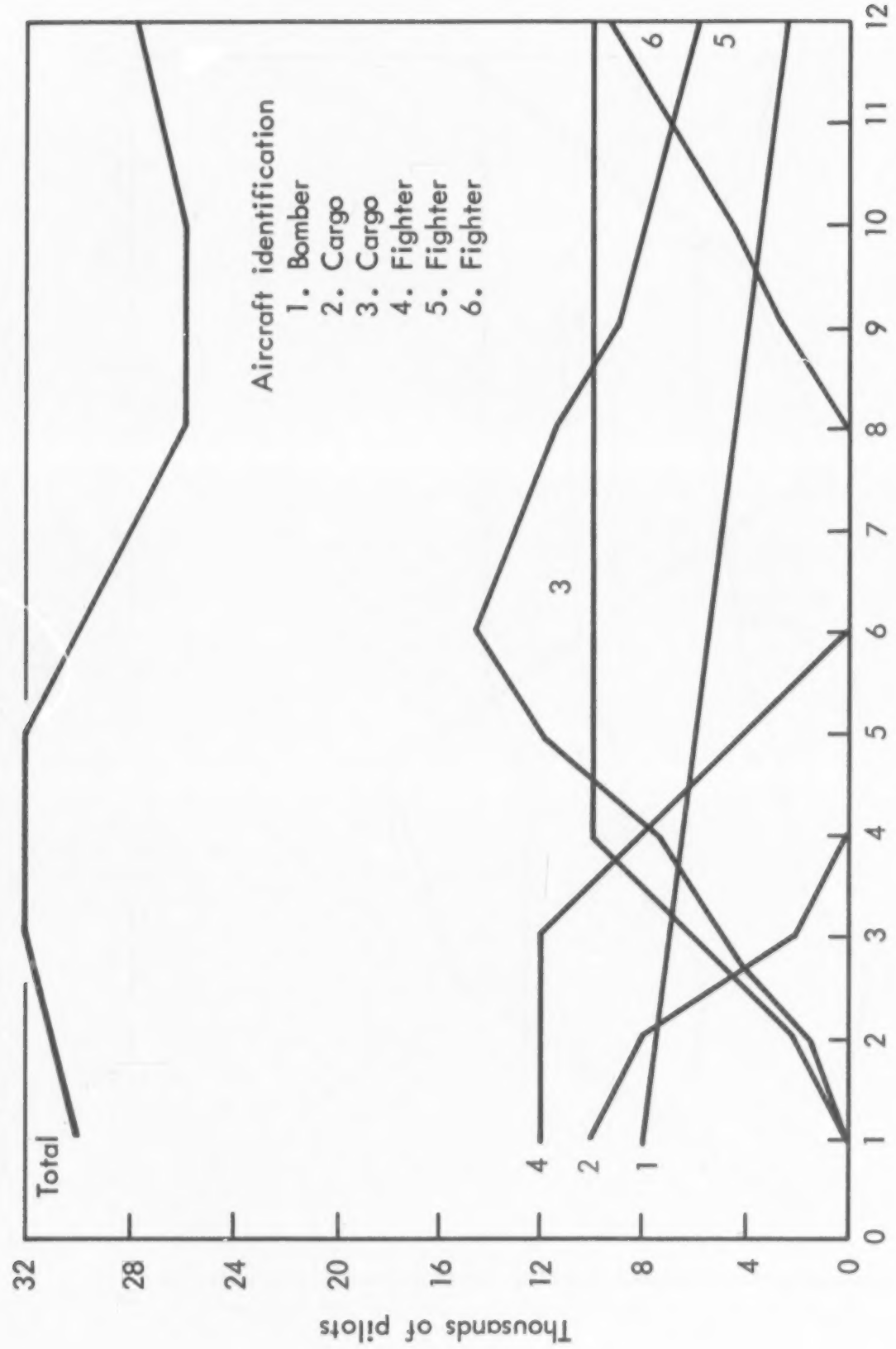

Fig. 18—Pilot requirements

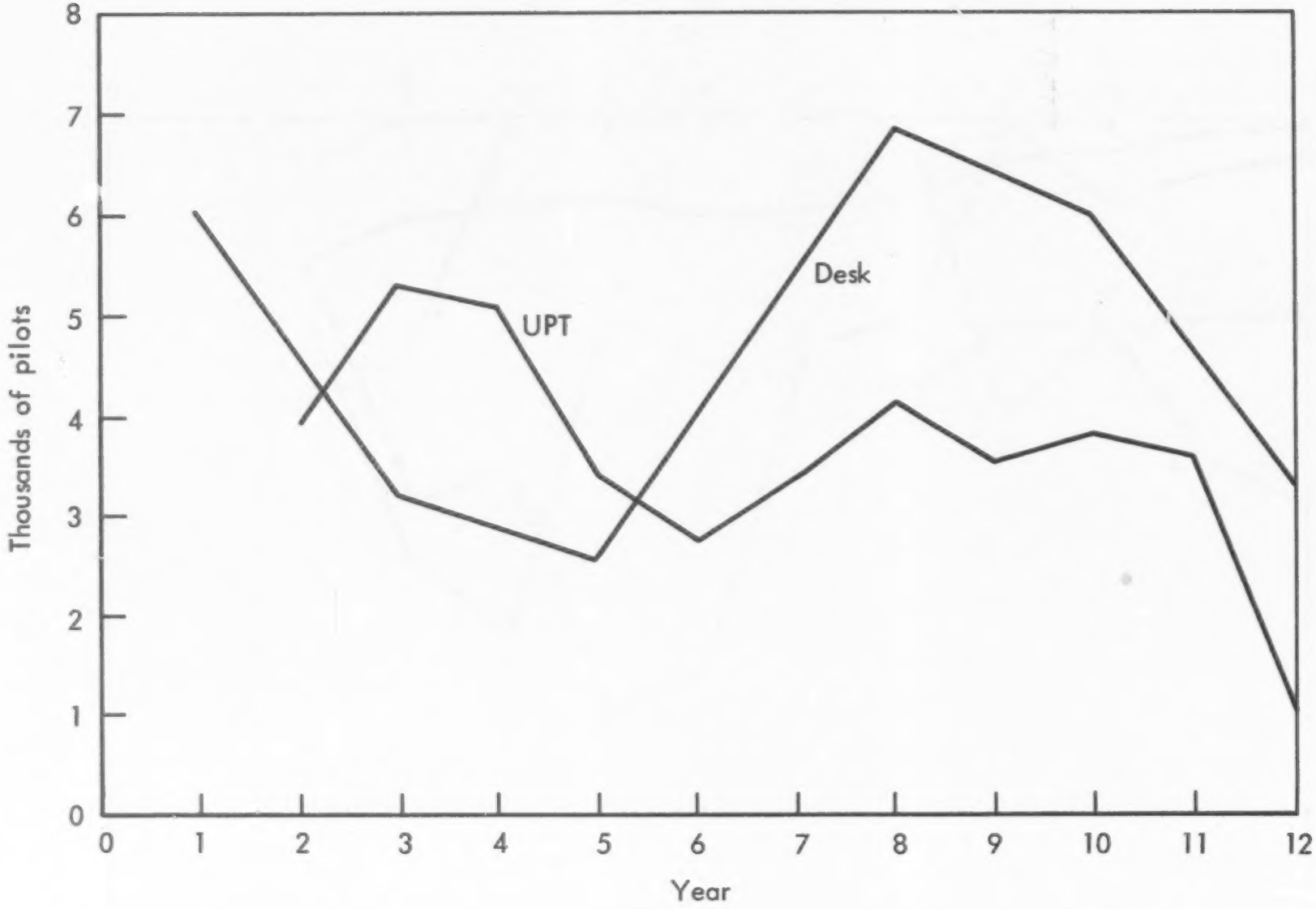

Fig. 19—UPT training load and number of pilots in desk jobs

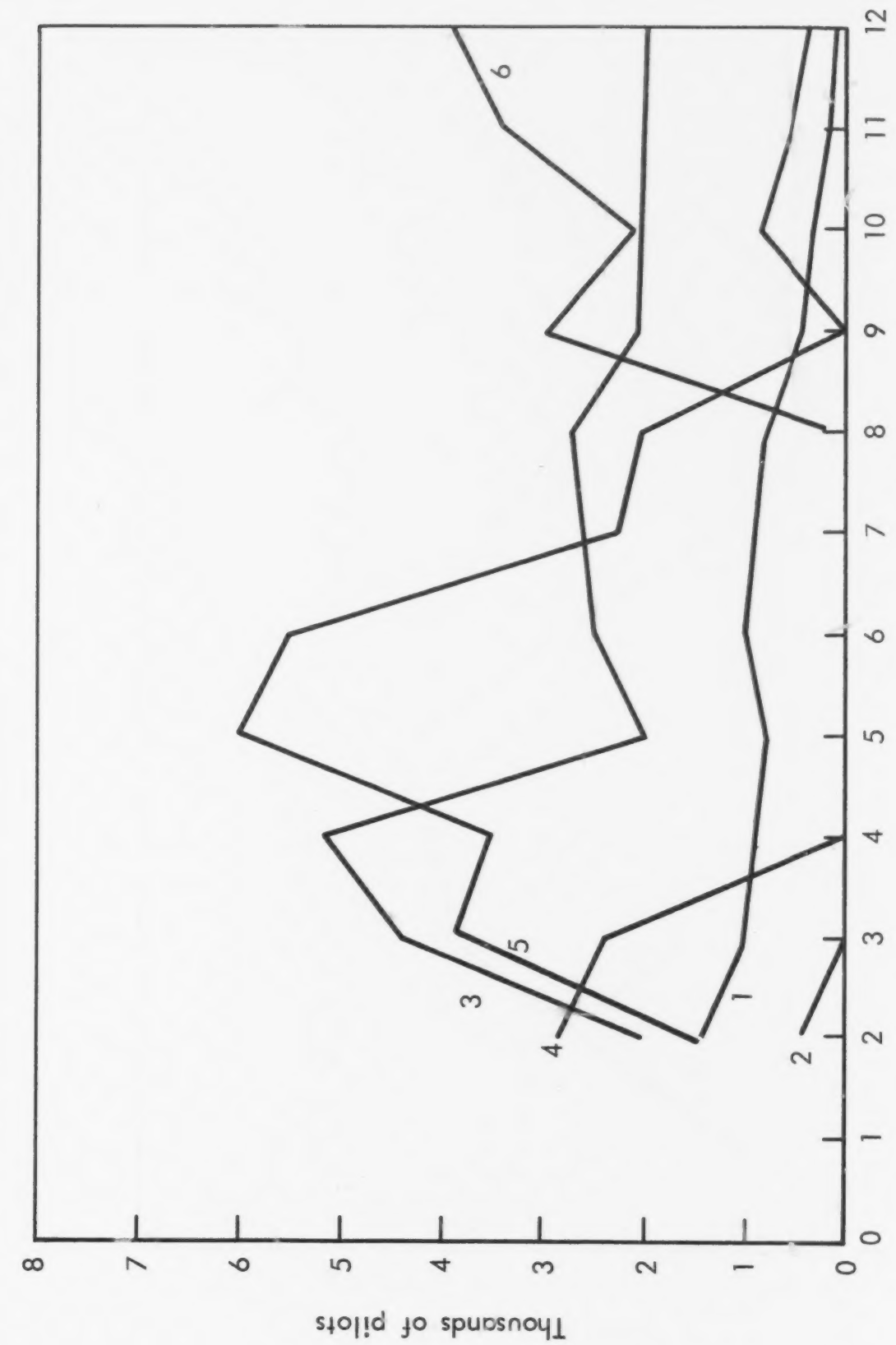

Fig. 20—APT training l

Figure 19 illustrates outputs of the requirements through UPT, and the size of the supplement. Figure 20 displays the flow of pilots through advanced training. The pilot loss rates and the rates of rotation for career development have been held constant in this example from year to year and for all aircraft systems, but these may be varied as necessary to fit the analysis.

This example points to the importance of the level of detail used in the analysis. The total force size in this example is the same as that of the more aggregate case shown in Figs. 11 through 16, but the requirements through UPT and APT are different due to level of detail. When the requirements for pilots are aggregated, the analysis must also aggregate the time required for advanced flying training. This is equivalent to stating that the length of all advanced flying training courses is the same, which, of course, is not correct. The assumption results in an even flow from UPT, as shown in Fig. 14. In contrast, when the input data include several different lengths of time for advanced training, those pilots that attend the longer courses must graduate from UPT before those attending shorter courses, causing the UPT requirements to appear as shown in Fig. 19. The same reasons affect the number of pilots in advanced training, and this may be seen by comparing Fig. 14 and Fig. 20.

As a general rule, broad areas of interest should be tested using the "total pilot" approach. Cases that prove uninteresting or not feasible should be discarded, since nothing will be gained by using more detail. Cases that are of interest can then be investigated using the more detailed approach.

The cost of training pilots in any single segment of the pilot training process may be estimated using a resource and cost model simulating the particular segment. Questions regarding the total cost of pilot training in the Air Force cannot be addressed with the resource and cost models alone, because the load of students in each training activity is a function of flow patterns within the Air Force that are related to natural factors such as pilot loss rates, and policy factors, such as force size and pilot rotation. The PILOT model provides a means of estimating the flow of pilots as a function of these factors,

and of estimating the loads in each of the training activities. With this information, the total cost of pilot training may be estimated.

Appendix

AUXILIARY ROUTINES FOR USE WITH THE PILOT MODEL

The PILOT model was developed to integrate a series of resource and cost models into a structure simulating the pilot training activities of the Air Force. The resource and cost models cover the various training activities which play a role in the production of pilots, such as commission training, undergraduate pilot training, survival school, and combat crew training.

The PILOT model simulates the flow of people through these training activities. Simply stated, given the requirements for pilots over time, and a policy governing the career of these pilots, the PILOT model structures the required training and produces a schedule of entrants and graduates for each of the training activities. Together with the resource and cost models, it relates the size and cost of the training establishment to the need for pilots to operate and support aircraft.

A number of options are available to the user of the PILOT model which are a result of its simulation of the Air Force. For example, there is the ability to simulate career development for pilots by allowing them to rotate from duty as pilots to management positions at desks. Conversely, cockpit requirements may be filled by rotating pilots occupying desk jobs back into flying positions. Also, since a supplement of pilots is maintained as an internal reserve for surges in requirements, the PILOT model maintains a running inventory of this supplement as pilots in desk jobs.

Of the inputs to the PILOT model, the following may be considered driving forces:

A1 - pilot requirements.

A4, A5 - pilot loss rates. This includes losses from the service and transfers from flying status to nonflying status.

A2 - the fraction of net pilot requirements that are desired from undergraduate pilot training and advanced pilot training (in contradistinction to pilots who are cross-trained).

A5 - the pilot transfer rate from weapon systems to desk jobs.

These factors control:

- o The total number of pilots in the Air Force at any time,
- o The requirements for training new pilots,
- o The size of the supplement of pilots occupying desk jobs,
- o The rate of rotation of pilots through desk jobs as part of their career development,
- o The requirements for cross-training,
- o The advanced flying training (APT) load.

Other inputs are largely factors specifying the length and internal-attrition rates of the various training activities.

Outputs from the PILOT model consist of tables of information concerning the various training activities, and include the required number of entrants and graduates by year from precommissioning training, Undergraduate Pilot Training (UPT), and the various Advanced Pilot Training Schools (APT). The output also includes a statement of the number of pilots in desk jobs for each year.

For most purposes, the input-output structure described above is satisfactory. There are, however, some problems that are difficult to treat explicitly with this format. These are problems in which one or more of the normal outputs are fixed. Examples of this are situations requiring a constant UPT output or a fixed number of pilots in desk jobs, or more broadly, the problem of duplicating a set of historical information in which all outputs are known. In these cases, it is necessary to have the ability to deduce the input factors from the desired outputs.

Several routines have been developed for this purpose. The routines consist essentially of the use of equations expressing relationships, between the inputs and outputs, needed to determine the proper input factors. Conditions under which the routines will operate are explained below.

The most important condition is that the requirement for pilots must be treated as a yearly Air Force total, rather than by weapon system and pilot type for each year, as is done in the PILOT model. This simplifies the routines but can cause a problem because requirements for pilots as a yearly Air Force total obscure the fact that within this total some weapon systems may be losing pilots and others

may be gaining them. The PILOT model omits negative requirements in its summation of pilot requirements. The routine being described does not perform at this level of detail, and inputs to it express only the net pilot requirements for a year. Thus, the statement of pilots required in the PILOT model will always be equal to or greater than the same statement used in the routine. For this reason, these input factors, when used in the PILOT model, will produce the same result (i.e., the same output as that from which derived) only under the following alternative conditions:

- o The Air Force must be treated in total, rather than by type of aircraft system, or
- o The data may be input in detail (i.e., by aircraft system) only if no reduction in pilot strength is programmed for any of the systems.

The PILOT model contains a preference routine for the selection of pilots for cross-training. It permits choices to be made from pilots of similar aircraft, pilots of dissimilar aircraft, and pilots in desk jobs. This ordering of preferences has no effect when input factors generated by the routines are used because in that case, desk jobs are the only source of pilots for cross-training. Therefore, when the routines are used and pilot requirements are stated as a net Air Force total, some cross-training from weapon system to weapon system may be unaccounted for. Unless this fact is appreciated, APT training requirements may be understated.

The next assumption was made to simplify the mathematics, and to accommodate the form of the available data. The PILOT model provides for the statement of loss rates of pilots in two forms. The first is the loss rate of pilots from weapon systems, and the second is the loss rate of pilots from desk jobs. Conceivably there is a genuine difference in these rates, and there may be data which identifies them separately. In the routines, the two rates have been considered as identical.

Assume there are no additional (less important) assumptions. The last assumption concerns A5A, the pilot transfer rate from weapon systems

to desk jobs. Pilots are transferred to desks for two reasons. One, there may be fewer flying jobs available than there are pilots to fill them. The number of flying jobs usually contracts after a major use of the force (Korea is an example). When the number of flying jobs shrinks, pilots are forced to take desk jobs. The second reason is that the Air Force circulates officers between weapon systems and desk jobs for career development purposes. In the PILOT model, as in the Air Force, this circulation is balanced; i.e., for each pilot transferred from cockpit to desk, one is transferred from desk to cockpit. Accomplishing this balance in the PILOT model requires adjustment of A2 and A5A, or, more specifically, A2 and the component of A5A that represents the flow of pilots for career development. The routines that are the subject of this appendix internally balance A2 and A5A, and provide the appropriate values of each. For each routine, however, it is necessary to input the value of A5A that is due to career development. Thus the user of the routine (and of the PILOT model) can select the degree of rotation through desk jobs for career development. The appropriate values of A5A and A2 are then calculated by the routine.

Flow charts of three routines for various inputs and outputs are shown in Figs. 21, 22, and 23. As might be expected, they are quite similar. They are easily adapted to use with JOSS,* which provides the flexibility and speed necessary to make multiple calculations. Sample JOSS programs are appended.

Examples of the use of these routines are helpful to demonstrate their utility, both with and without the PILOT model. Figure 24 illustrates some historical data for the period 1962-1968. The plot of "core" is the sum of those pilots categorized as "force," "supervisory," and "training" pilots. The plot of "desk" is synonymous with the "supplement." Undergraduate pilot training graduates are actual. While Fig. 24 is an historical plot, it could as well be any projected future situation, or any hypothetical one. From the data in Fig. 24 and the routine of Fig. 22, the input values of A2 and A5 which correspond to the given facts are easily determined; and if these factors

*JOSS is the trademark and service mark of The Rand Corporation for its computer program and services using that program.

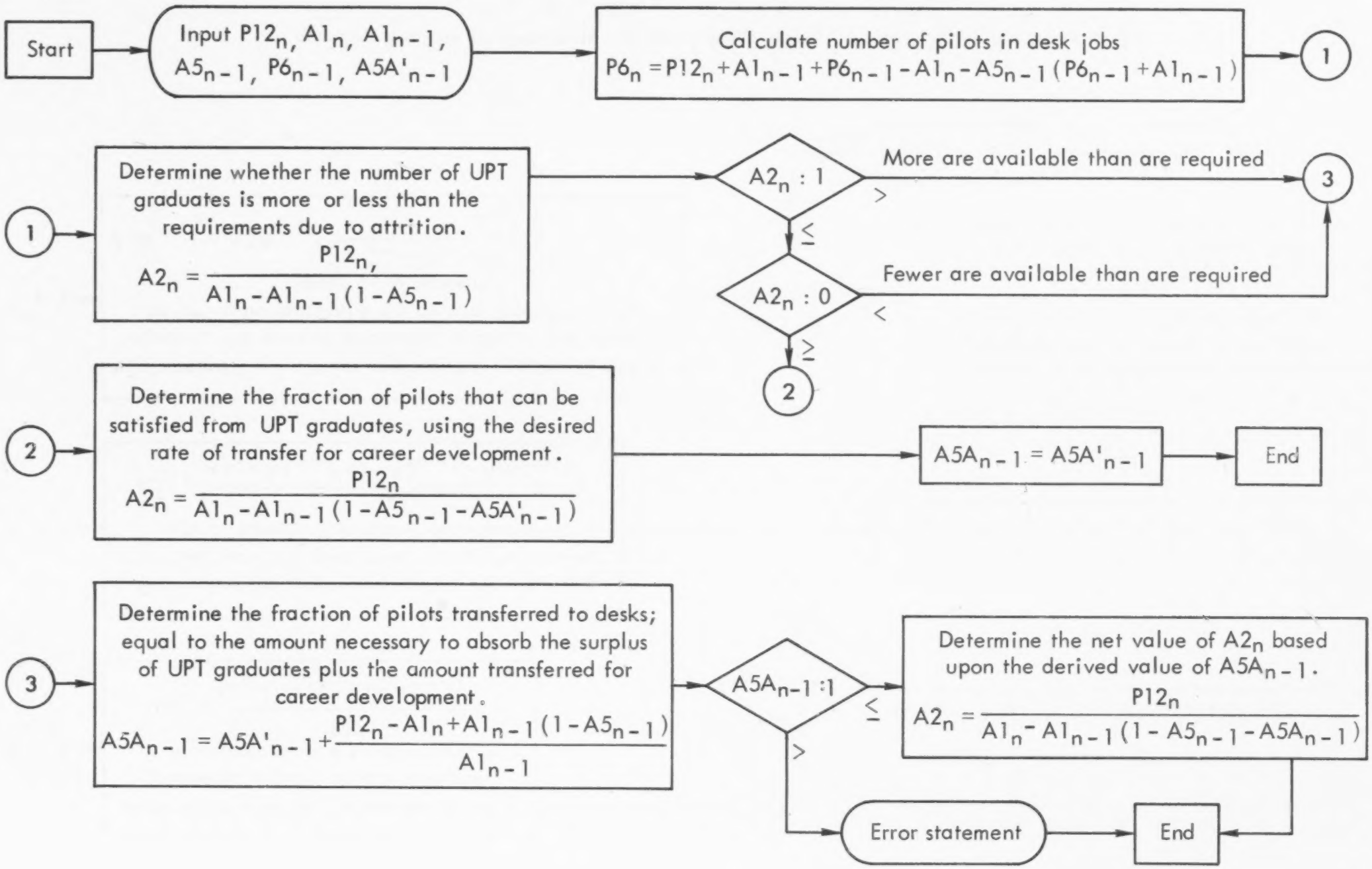
Start
Input $P12_n$, $A1_n$, $A1_{n-1}$, $A5_{n-1}$, $P6_{n-1}$, $A5A'_{n-1}$
Calculate number of pilots in desk jobs
$P6_n = P12_n + A1_{n-1} + P6_{n-1} - A1_n - A5_{n-1}(P6_{n-1} + A1_{n-1})$
1
Determine whether the number of UPT graduates is more or less than the requirements due to attrition.
$A2_n = \frac{P12_n}{A1_n - A1_{n-1}(1 - A5_{n-1})}$
$A2_n : 1$
More are available than are required
3
$A2_n : 0$
Fewer are available than are required
2
Determine the fraction of pilots that can be satisfied from UPT graduates, using the desired rate of transfer for career development.
$A2_n = \frac{P12_n}{A1_n - A1_{n-1}(1 - A5_{n-1} - A5A'_{n-1})}$
$A5A_{n-1} = A5A'_{n-1}$
End
Determine the fraction of pilots transferred to desks; equal to the amount necessary to absorb the surplus of UPT graduates plus the amount transferred for career development.
$A5A_{n-1} = A5A'_{n-1} + \frac{P12_n - A1_n + A1_{n-1}(1 - A5_{n-1})}{A1_{n-1}}$
$A5A_{n-1} : 1$
Determine the net value of $A2_n$ based upon the derived value of $A5A_{n-1}$.
$A2_n = \frac{P12_n}{A1_n - A1_{n-1}(1 - A5_{n-1} - A5A_{n-1})}$
Error statement
End

Fig. 21 — Routine to determine values of $A2_n$, $A5A_{n-1}$ and $P6_n$ from inputs of $P12_n$, $A1_n$, $A1_{n-1}$, $A5_{n-1}$, $A5A_{n-1}$, and $P6_{n-1}$

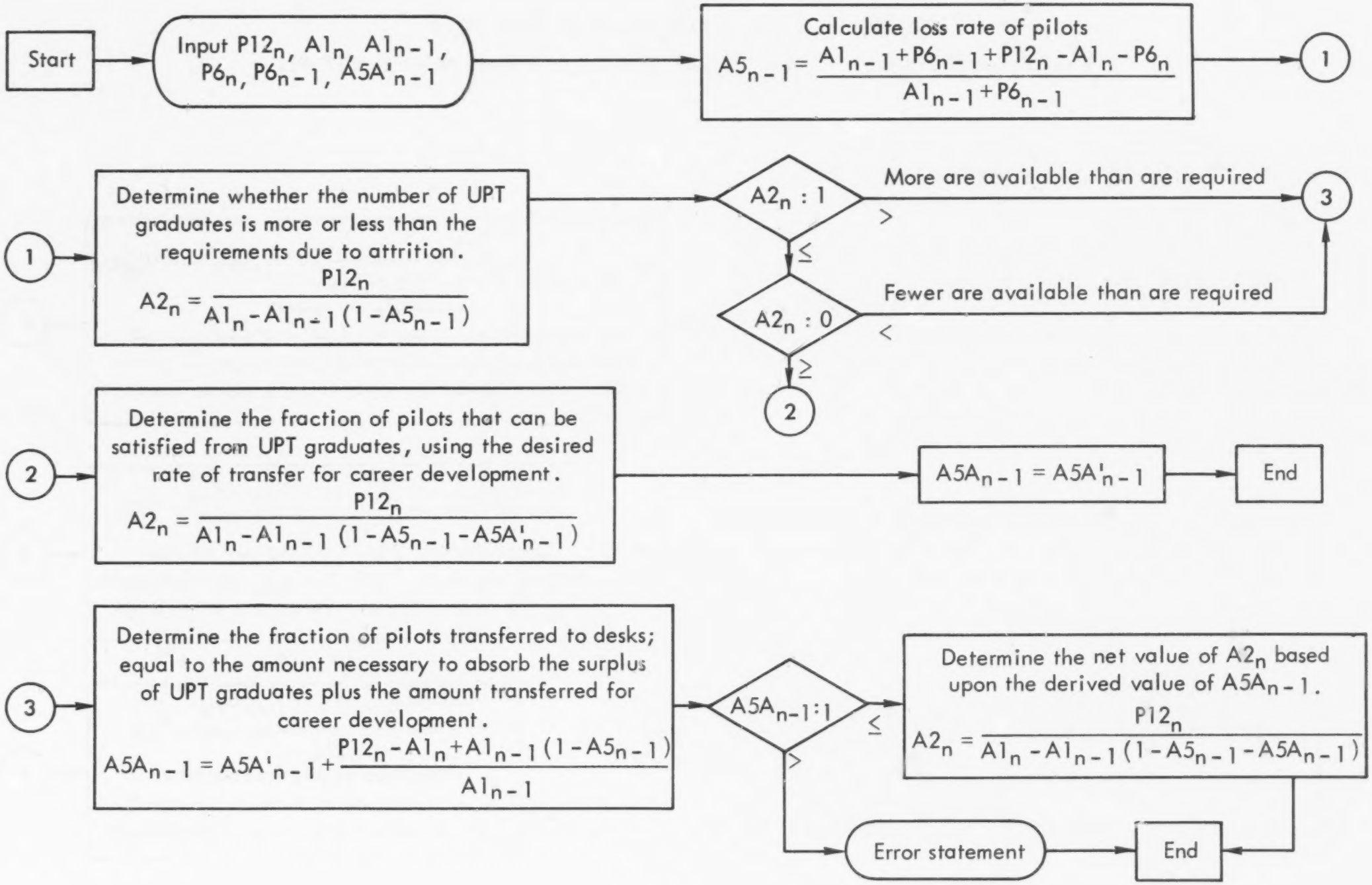
Start
Input $P12_n$, $A1_n$, $A1_{n-1}$, $P6_n$, $P6_{n-1}$, $A5A'_{n-1}$
Calculate loss rate of pilots
$A5_{n-1} = \frac{A1_{n-1} + P6_{n-1} + P12_n - A1_n - P6_n}{A1_{n-1} + P6_{n-1}}$
1
1
Determine whether the number of UPT graduates is more or less than the requirements due to attrition.
$A2_n = \frac{P12_n}{A1_n - A1_{n-1}(1 - A5_{n-1})}$
$A2_n : 1$
More are available than are required
>
3
≤
$A2_n : 0$
Fewer are available than are required
<
≥
2
2
Determine the fraction of pilots that can be satisfied from UPT graduates, using the desired rate of transfer for career development.
$A2_n = \frac{P12_n}{A1_n - A1_{n-1}(1 - A5_{n-1} - A5A'_{n-1})}$
$A5A_{n-1} = A5A'_{n-1}$
End
3
Determine the fraction of pilots transferred to desks; equal to the amount necessary to absorb the surplus of UPT graduates plus the amount transferred for career development.
$A5A_{n-1} = A5A'_{n-1} + \frac{P12_n - A1_n + A1_{n-1}(1 - A5_{n-1})}{A1_{n-1}}$
$A5A_{n-1} : 1$
≤
Determine the net value of $A2_n$ based upon the derived value of $A5A_{n-1}$.
$A2_n = \frac{P12_n}{A1_n - A1_{n-1}(1 - A5_{n-1} - A5A_{n-1})}$
>
Error statement
End

Fig. 22 — Routine to determine values of $A2_n$, $A5A_{n-1}$ and $A5_{n-1}$ from inputs of $P12_n$, $A1_n$, $A1_{n-1}$, $P6_n$, $A5A_{n-1}$, and $P6_{n-1}$.

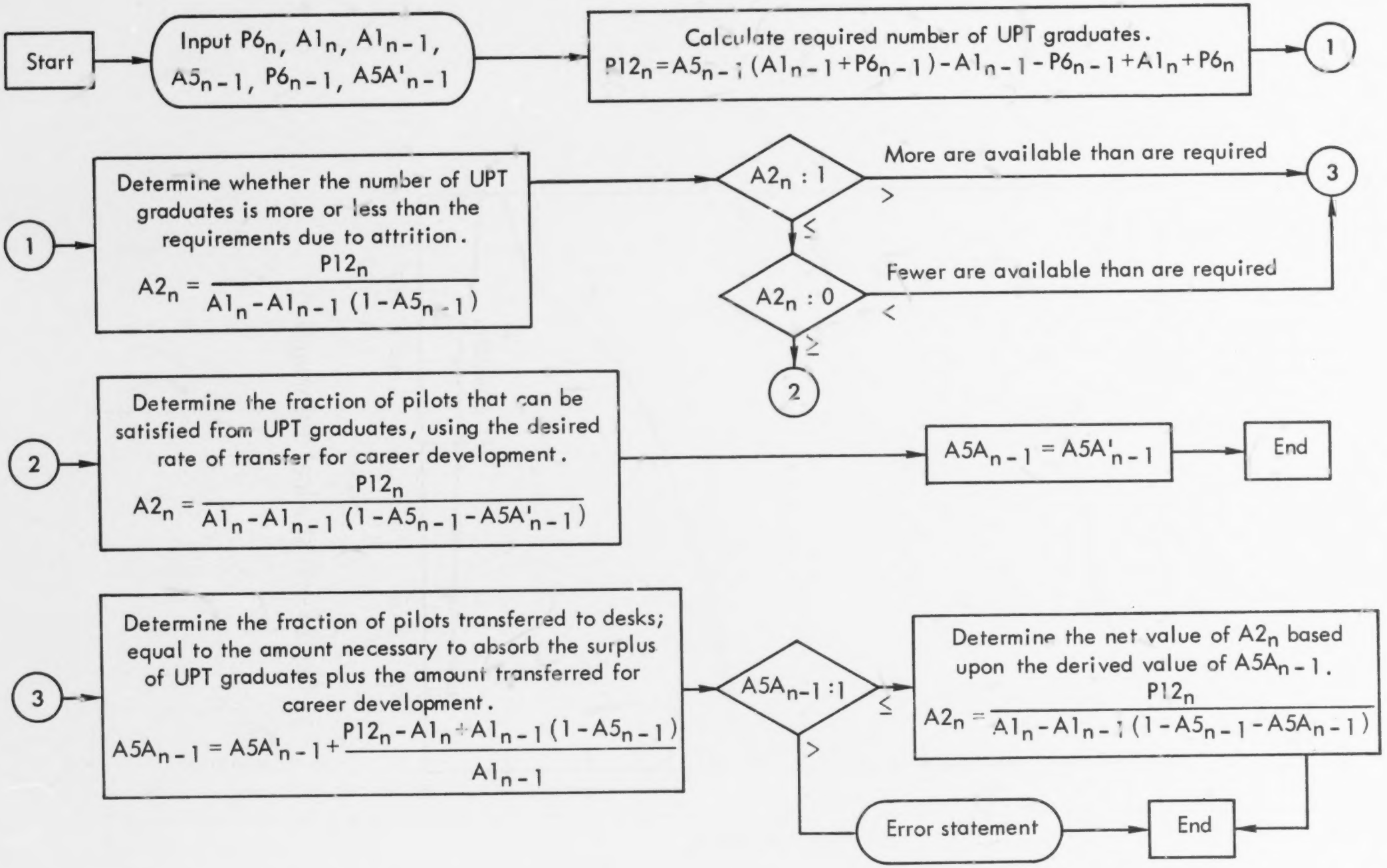
Start
Input $P6_n$, $A1_n$, $A1_{n-1}$, $A5_{n-1}$, $P6_{n-1}$, $A5A'_{n-1}$
Calculate required number of UPT graduates.
$P12_n = A5_{n-1}(A1_{n-1} + P6_{n-1}) - A1_{n-1} - P6_{n-1} + A1_n + P6_n$
1
Determine whether the number of UPT graduates is more or less than the requirements due to attrition.
$A2_n = \frac{P12_n}{A1_n - A1_{n-1}(1 - A5_{n-1})}$
$A2_n : 1$
More are available than are required
>
3
≤
$A2_n : 0$
Fewer are available than are required
<
≥
2
2
Determine the fraction of pilots that can be satisfied from UPT graduates, using the desired rate of transfer for career development.
$A2_n = \frac{P12_n}{A1_n - A1_{n-1}(1 - A5_{n-1} - A5A'_{n-1})}$
$A5A_{n-1} = A5A'_{n-1}$
End
3
Determine the fraction of pilots transferred to desks; equal to the amount necessary to absorb the surplus of UPT graduates plus the amount transferred for career development.
$A5A_{n-1} = A5A'_{n-1} + \frac{P12_n - A1_n + A1_{n-1}(1 - A5_{n-1})}{A1_{n-1}}$
$A5A_{n-1} : 1$
≤
Determine the net value of $A2_n$ based upon the derived value of $A5A_{n-1}$.
$A2_n = \frac{P12_n}{A1_n - A1_{n-1}(1 - A5_{n-1} - A5A_{n-1})}$
>
Error statement
End

Fig. 23 — Routine to determine values of $A2_n$, $A5A_{n-1}$ and $P12_n$ from inputs of $P6_n$, $A1_n$, $A1_{n-1}$, $A5_{n-1}$, $A5A_{n-1}$, and $P6_{n-1}$.

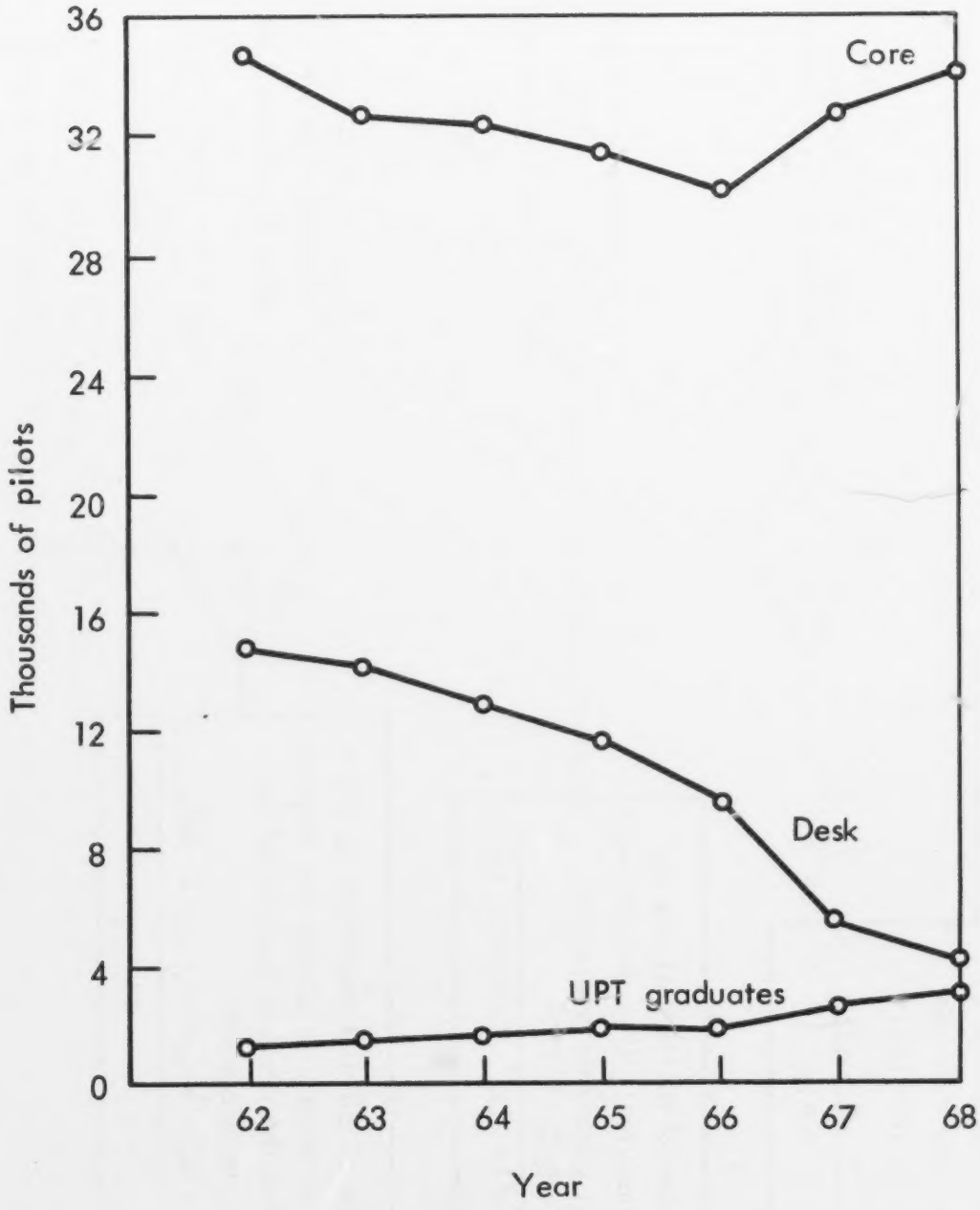

Fig. 24—Historical information

are used in the PILOT model, the output data covering the number of pilots in desk jobs and the number of UPT graduates will agree exactly with Fig. 24.

The question might well be asked: Of what use is this? First, the routines have developed the personnel attrition rates that fit the data, and also the net flow of personnel to or from desk jobs. Second, using the information together with the PILOT model, the flow of pilots for career development purposes can be simulated, and the required load on APT estimated. Figure 25 repeats the data of Fig. 24, but shows the APT load based on several levels of flow for career development. The peak demand indicated for APT in 1967 shows a minimum requirement through APT of about 5700 under conditions of no rotation for career development, caused largely by the sudden increase in pilot requirements. Rotation for career development adds to this minimum APT load, and the ability to present this information graphically, together with knowledge of APT capacity and budget constraints, should allow planners to adjust the career development rotation as necessary.

Figure 26 presents a hypothetical situation which is more typical. The size of the core is known, and the size of the desired supplement is known. The question is: What level of UPT output and APT training must be maintained in order to balance these known quantities? The answer is a function of the attrition or loss rate and the rotation rate for career development. Using the routine of Fig. 23 and the PILOT model, and several appropriate values for the attrition rate and rotation rate, the results shown in Fig. 27 are obtained. It is seen that fixing the size of the supplement for each year in the face of changing core requirements causes great changes in the number of UPT graduates required. When using the range of attrition rates that might realistically be encountered, one finds that the UPT graduate requirements range from about 900 to about 5400--a span large enough to require opening and closing UPT bases. Clearly this is a situation in which planners must either accept this drastic action or reduce the size of either the core or the supplement.

The routine shown in Fig. 22 can be used when the size of the core and the UPT output are known. Figure 28 illustrates the variation in

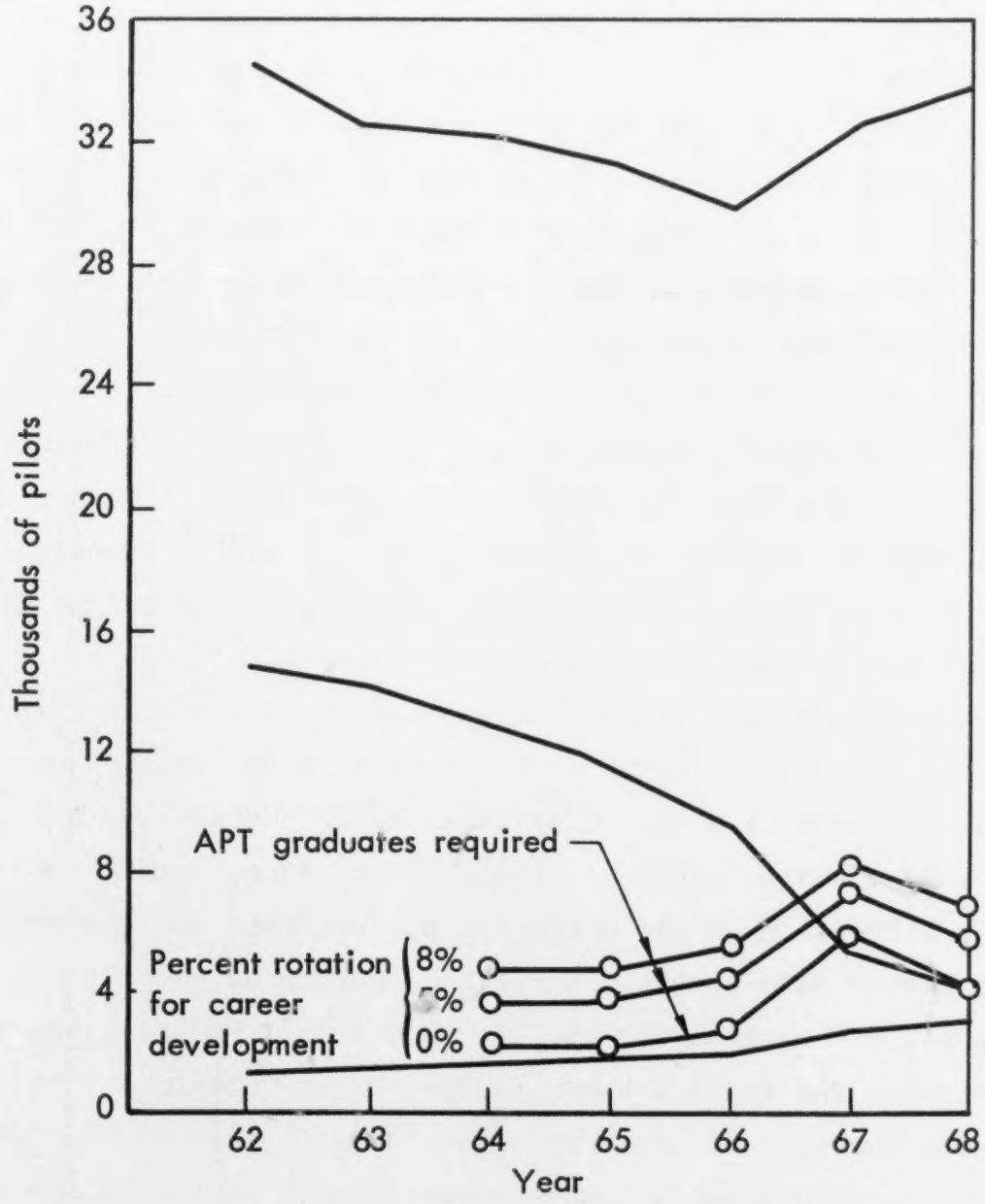

Fig. 25—APT load as a function of career development rotation

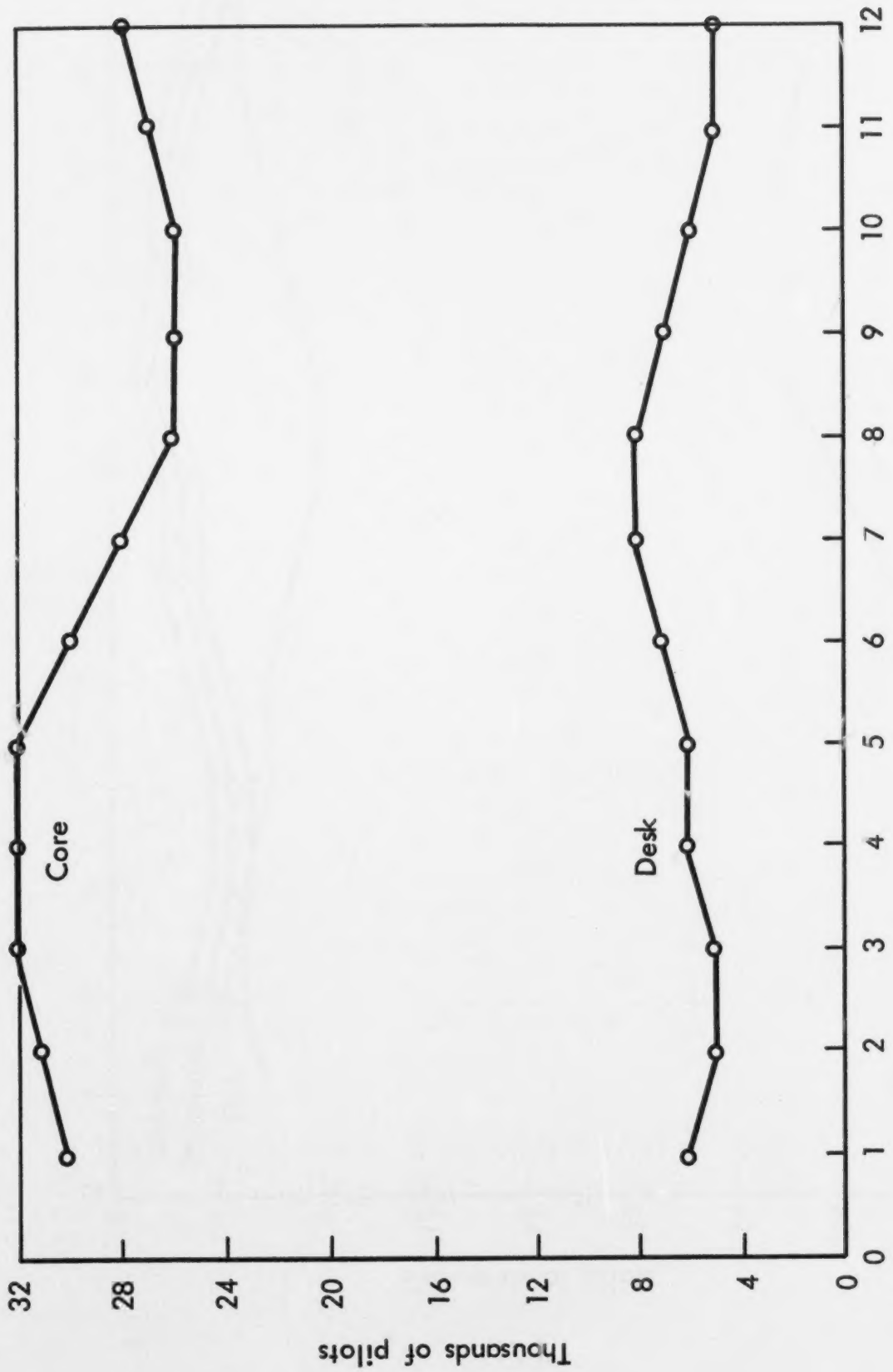

Fig. 26—Hypothetical plan for total number of pilots

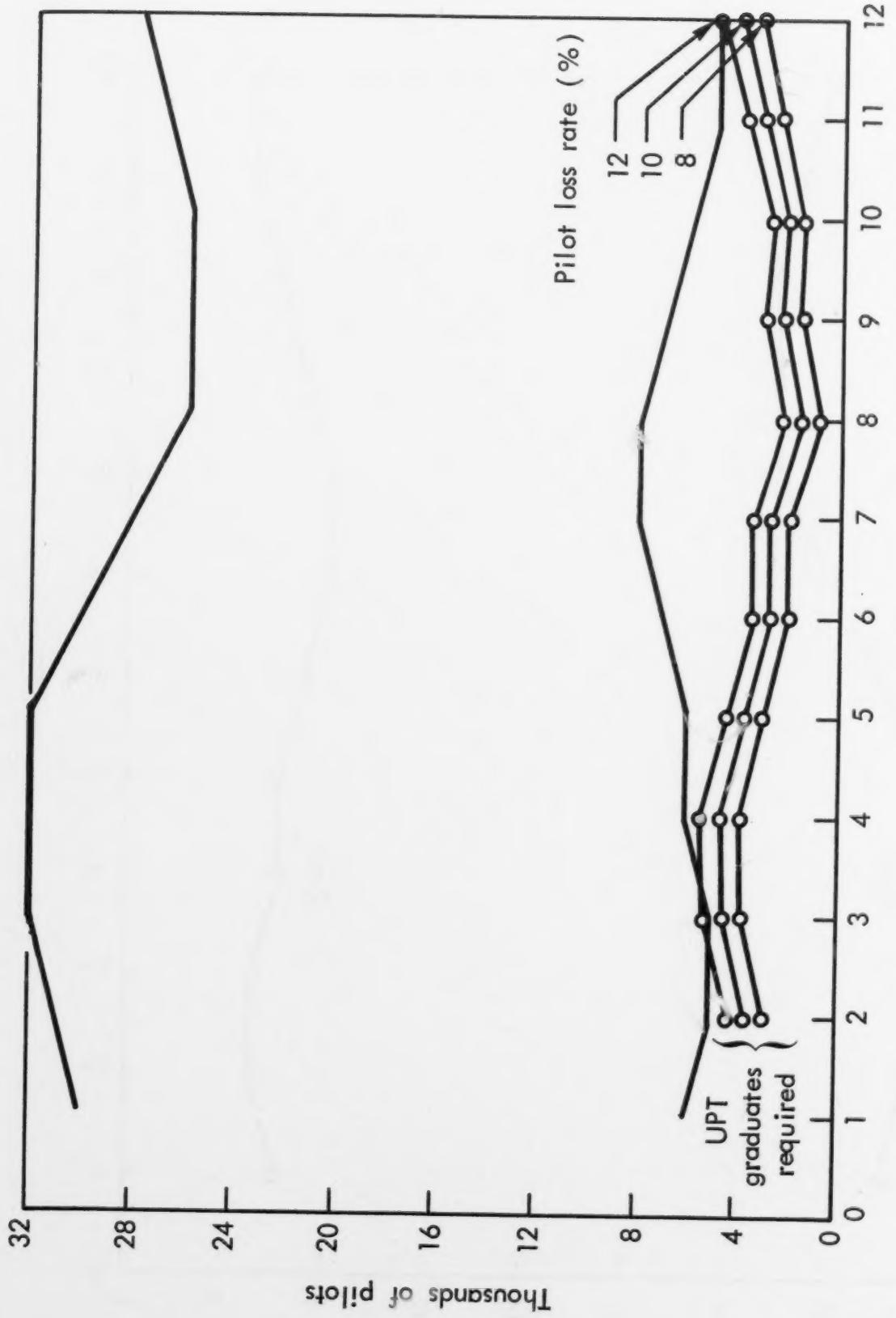

Fig. 27—UPT graduate requirements to fulfill plan of Fig. 26, as a function of pilot loss rate

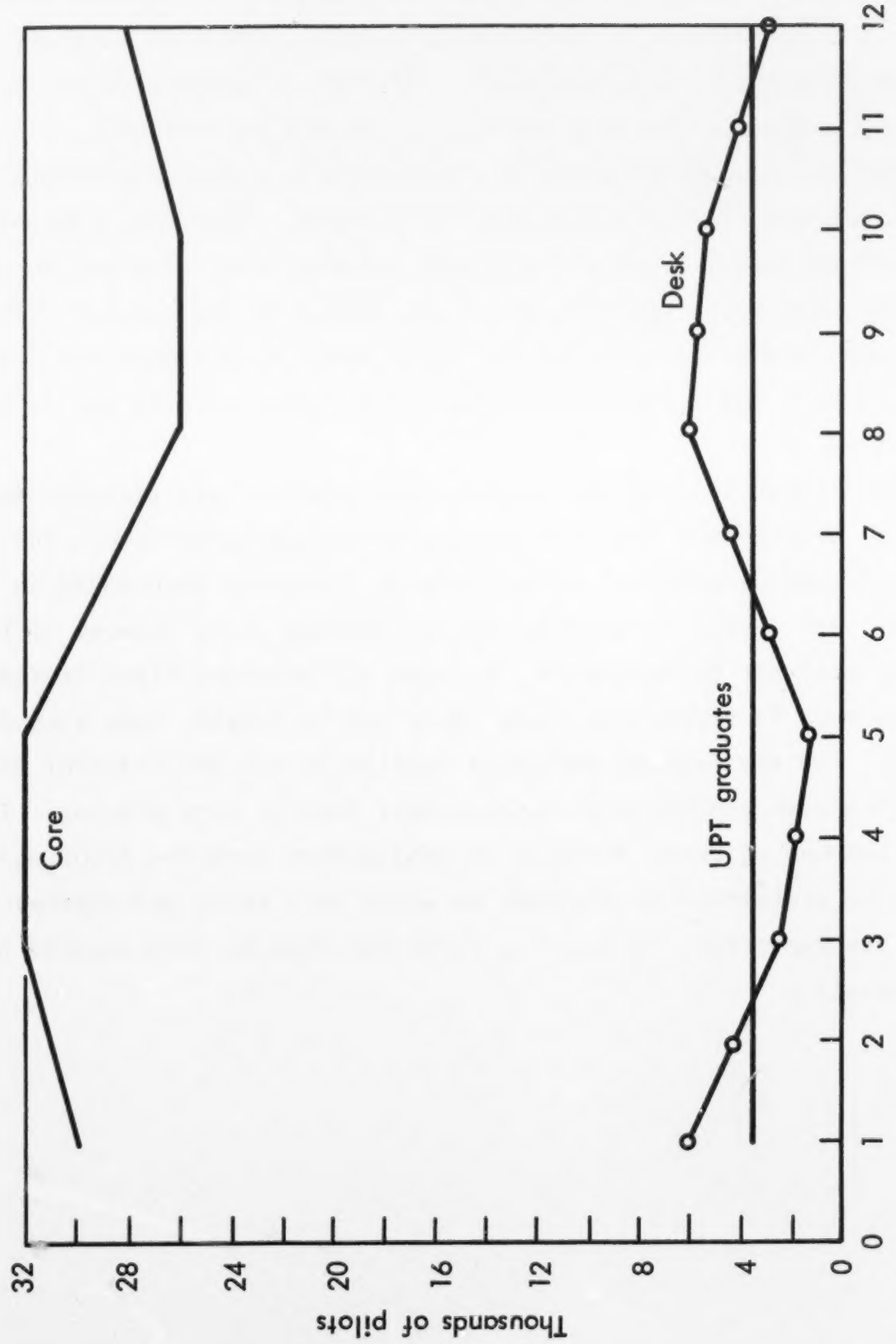

Fig. 28—Variation of number of pilots in desk jobs when UPT production level is held constant, and size of core varies

the supplement which occurs in the case where the core is the same size as Fig. 26, but where the UPT output is fixed at 3500 graduates per year. All variations in requirements(ranging from 6000 to about 1300) must be absorbed by the supplement. If this is unsatisfactory for planning purposes, the relevant factors should be reviewed.

The routines illustrated in this document cannot substitute for the detail and flexibility of the PILOT model. They can, however, aid users of the model by providing rapid assessment of alternative manning concepts upon pilot training at a high degree of aggregation. The routines also enable the user of the PILOT model to estimate the correct input factors for conditions in which some known outputs are to be duplicated.

The limitations on the use of these routines are restated for emphasis. Because the routines operate at an aggregate level, the flows of pilots may be expected to be somewhat different than would be found if they were viewed in detail. Cross-training flows between aircraft systems will not be expressed. Because all Advanced Pilot Training courses must be treated as being identical in length, some time phasing is lost, and the factors for pilot loss rates and the transfer of pilots from core to desk will reflect this loss of time phasing. In general, the use of these routines in conjunction with the PILOT model should be restricted to analyses in which only broad and aggregate concepts are explored. Interesting cases can then be investigated in further detail.

ROUTINE CORRESPONDING TO FIG. 21

```
1.0 Type "This program derives values for A2, A5A, and P6 when the number".
1.1 Type "of UPT graduates (P12) is given.  The value of A5A derived".
1.2 Type "includes a component that is based upon the flow of pilots".
1.3 Type "from core to desks that is required to accommodate the UPT".
1.4 Type "graduates when these are in excess of the requirements due".
1.5 Type "to attrition, and a component which is input as the desired".
1.6 Type "flow of pilots from core to desks for career development.".
1.61 Type " Inputs required are".
1.62 Type "   P12(n), the UPT graduates in year n,".
1.63 Type "   A1(n), the pilot requirements (core) in year n,".
1.64 Type "   A1(n-1), the pilot requirements (core) in year n-1,".
1.65 Type "   A5(n-1), the fractional pilot attrition out of the force".
1.66 Type "    in year n-1,".
1.67 Type "   A5A(n-1)( for career development), the fraction of the".
1.68 Type "    pilots in the core that rotate to desks in year n,".
1.681 Type "   P6(n-1), the number of pilots in desks in year n-1,".
1.69 Type " Outputs are".
1.691 Type "  A2(n), the fraction of pilots desired from UPT in year n,".
1.692 Type "  A5A(n-1), the fraction of pilots rotated to desks in ".
1.693 Type "   year n-1.".
1.694 Type "   P6(n), the number of pilots in desks in year n.".
1.75 Line.
1.8 To part 2.

2.0 Demand A as "P12(n)".
2.1 Demand B as "A1(n)".
2.2 Demand C as "A1(n-1)".
2.3 Demand D as "A5(n-1)".
2.4 Demand E as "A5A(n-1) for career development".
2.401 Demand F as "P6(n-1)".
2.41 Let G=A+C+F-B-D•(C+F).
2.45 Line.
2.5 To part 3.

3.0 Let X=A/[B-C•(1-D)].
3.1 To part 4 if 0<X≤1.
3.2 To part 5 if X>1 or X<0.

4.0 Let X=A/[B-C•(1-D-E)].
4.1 Type form 1.
4.15 Type X,E,G in form 2.
4.16 Line.
4.2 To part 2.

5.0 Let Y=[A-B+C•(1-D)]/C+E.
5.05 To part 7 if Y>1.
5.1 Let X=A/[B-C•(1-Y-D)].
```

```
5.2 To part 6 if X<0 or X≥1.
5.3 Type form 1.
5.35 Type X,Y,G in form 2.
5.36 Line.
5.4 To part 2.

6.0 Set X=1.
6.1 Type form 1.
6.15 Type X,Y,G in form 2.
6.16 Line.
6.2 To part 2.

7.0 Type "A5A>1. Please change inputs so that A1(n)≥P12(n).".
7.1 To part 2.

Form 1:
A2(n)          A5A(n-1)          P6(n)

Form 2:
__._____       __._____          _____.__
```

ROUTINE CORRESPONDING TO FIG. 22

```
1.0 Line.
1.01 Type " This program derives values for A2, A5, and A5A when the".
1.02 Type "number of UPT graduates (P12) and the number of pilots".
1.03 Type "in desk jobs (P6) are fixed. The values of A2 and A5A".
1.04 Type "produced reflect the net flow of pilots from desk to core".
1.05 Type "or vice-versa due to pilot requirements, and also the flow".
1.06 Type "due to career development.  The value of A5 derived reflects".
1.07 Type "the attrition from the service that is necessary to bring".
1.08 Type "the other fixed inputs into balance.".
1.09 Type "   Inputs required are".
1.091 Type "   P12(n), the UPT graduates in year n,".
1.092 Type "   A1(n), the pilot requirements (core) in year n,".
1.093 Type "   A1(n-1), the pilot requirements (core) in year n-1,".
1.094 Type "   A5A(n-1)(for career development), the fraction of the".
1.095 Type "    pilots in the core that rotate to desks in year n,".
1.096 Type "   P6(n-1), the number of pilots in desk jobs in year n-1".
1.097 Type "   P6(n), the number of pilots in desk jobs in year n.".
1.1   Type " Outputs are".
1.2   Type "   A2(n), the fraction of pilots desired from UPT in year n,".
1.3   Type "   A5A(n-1), the fraction of pilots rotated to desks".
1.4   Type "    in year n-1,".
1.5   Type "   A5(n-1), the fractional attrition rate of pilots ".
1.51  Type "   leaving the service in year n-1.".
1.75 Line.
1.8 To part 2.

2.0 Demand A as "P12(n)".
2.1 Demand B as "A1(n)".
2.2 Demand C as "A1(n-1)".
2.4 Demand E as "A5A(n-1) for career development".
2.41 Demand F as "P6(n-1)".
2.411 Demand G as "P6(n)".
2.42 Let D=(C+F+A-B-G)/(C+F).
2.45 Line.
2.5 To part 3.

3.0 Let X=A/[B-C•(1-D)].
3.1 To part 4 if X≤1.
3.2 To part 5 if X>1.

4.0 Let X=A/[B-C•(1-D-E)].
4.1 Type form 1.
4.15 Type X,E,D in form 2.
4.16 Line.
4.2 To part 2.

5.0 Let Y=[A-B+C•(1-D)]/C+E.
5.05 To part 7 if Y>1.
```

```
5.1 Let X=A/[B-C•(1-Y-D)].
5.2 To part 6 if X<0 or X>1.
5.3 Type form 1.
5.35 Type X,Y,D in form 2.
5.36 Line.
5.4 To part 2.

6.0 Set X=1.
6.1 Type form 1.
6.15 Type X,Y,D in orm 2.
6.16 Line.
6.2 To part 2.

7.0 Type "A5A>1. Please change inputs so that A1(n)≥P12(n).".
7.1 To part 2.

Form 1:
A2(n)          A5A(n-1)          A5(n-1)

Form 2:
__.____      __.____          __.____
```

ROUTINE CORRESPONDING TO FIG. 23

```
1.0 Line.
1.01 Type " This program derives values for A2, A5A, and P12 when the".
1.02 Type "attrition losses of pilots from the service and the numbers".
1.03 Type "of pilots in desk jobs are fixed.  The values of A2 and A5A".
1.04 Type "produced reflect the net flow of pilots from desk jobs to the ".
1.05 Type "core or vice-versa due to pilot requirements, and also the flow".
1.06 Type "due to career development.  The value of P12 derived is the".
1.07 Type "required number of UPT graduates that balances the fixed".
1.08 Type "inputs.".
1.09 Type "   Inputs required are".
1.091 Type "   A5(n-1), the fractional attrition rate of pilots leaving".
1.0911 Type "   the service in year n-1,".
1.092 Type "   A1(n), the pilot requirements (core) in year n,".
1.093 Type "   A1(n-1), the pilot requirements (core) in year n-1,".
1.094 Type "   A5A(n-1)(for career development), the fraction of the".
1.095 Type "    pilots in the core that rotate to desks in year n,".
1.096 Type "   P6(n-1), the number of pilots in desk jobs in year n-1".
1.097 Type "   P6(n), the number of pilots in desk jobs in year n.".
1.1   Type " Outputs are".
1.2   Type "   A2(n), the fraction of pilots desired from UPT in year n,".
1.3   Type "   A5A(n-1), the fraction of pilots rotated to desks".
1.4   Type "    in year n-1,".
1.5 Type "   P12(n), the number of UPT graduates required in year n,".
1.75 Line.
1.8 To part 2.

2.0 Demand D as "A5(n-1)".
2.1 Demand B as "A1(n)".
2.2 Demand C as "A1(n-1)".
2.4 Demand E as "A5A(n-1) for career development".
2.41 Demand F as "P6(n-1)".
2.411 Demand G as "P6(n)".
2.42 Let A=D•(C+F)-C-F+B+G.
2.45 Line.
2.5 To part 3 if A≥0.
2.6 To part 7 if A<0.

3.0 Let X=A/[B-C•(1-D].
3.1 To part 4 if X≤1.
3.2 To part 5 if X>1.

4.0 Let X=A/[B-C•(1-D-E)].
4.05 To part 7 if X<0.
4.1 Type form 1.
4.15 Type X,L,A in form 2.
4.16 Line.
4.2 To part 2.

5.0 Let Y=[A-B+C•(1-D)]/C+E.
```

```
5.1 Let X=A/[B-C•(1-Y-D)].
5.2 To part 6 if X<0 or X>1.
5.3 Type form 1.
5.35 Type X,Y,A in form 2.
5.36 Line.
5.4 To part 2.

6.0 Set X=1.
6.1 Type form 1.
6.15 Type X,Y,A in orm 2.
6.16 Line.
6.2 To part 2.

7.0 Type "P12(n)<0. Either A1(n-1)+P6(n-1) is too large, or A1(n)+P6(n)".
7.1 Type "is too small. Please adjust these inputs.".
7.2 To part 2.

Form 1:
A2(n)          A5A(n-1)          P12(n)

Form 2:
```

ERIC Clearinghouse
JUL 1 1971
on Adult Education